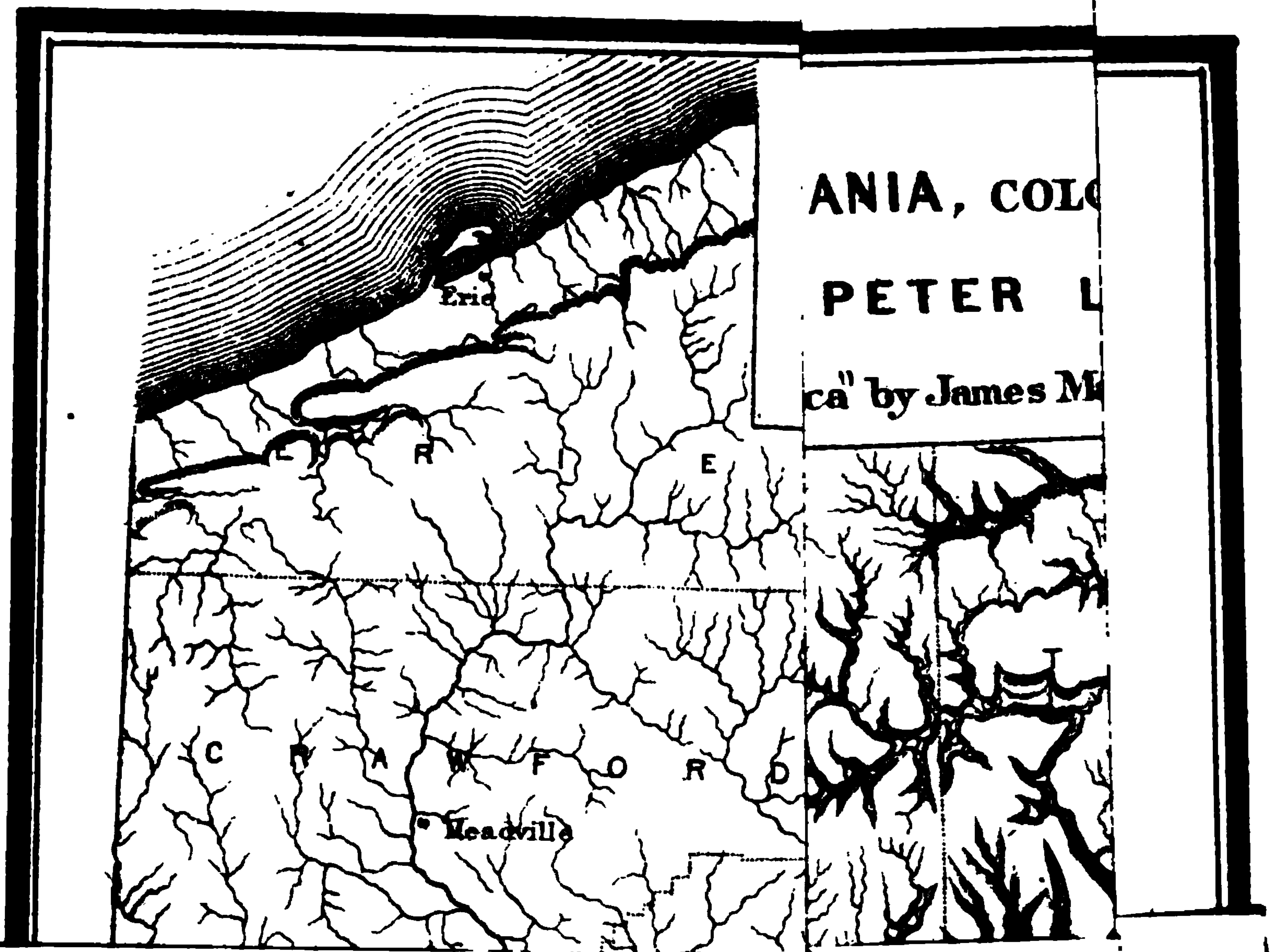
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THE

COAL-REGIONS OF AMERICA:

THEIR

TOPOGRAPHY, GEOLOGY, AND DEVELOPMENT.

WITH A COLORED GEOLOGICAL MAP OF PENNSYLVANIA, A RAILROAD MAP OF ALL THE COAL-REGIONS, AND NUMEROUS OTHER MAPS AND ILLUSTRATIONS.

BY

JAMES MACFARLANE, PH. D.

COMMISSIONER OF THE SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

THIRD EDITION,

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PREFACE.

THIS work is strictly confined to one subject, and that is expressed in the title. It is intended to be a collection of the principal useful facts and discoveries in regard to the Coal-Regions of the United States, their geographical situation, their topography, geology, and development, or their commercial and economical relations, properly classified for study or reference. Each of those States, within whose borders coal has been found, has at considerable expense caused geological surveys to be made of its own territory, conducted by some of our best geologists, who have spent years in examining and studying the coal-fields. These Government surveys are the basis of this work, and there can be no better authority on this subject. None of them are as complete as they should be, and some of them were very unwisely abandoned in an unfinished condition; yet, the numerous ponderous volumes of reports published, although not very attractive books to the general reader, contain a store of useful facts about coal, which should be condensed and digested in a convenient hand-book. The difficulties met with in collecting these materials have proved that there is a want of correct information accessible to the public, in a cheap and popular form, in regard to many of our coal-regions, particularly those producing bituminous coal. The older State Geological Reports are expensive and rare; all of

them are out of print, and there are but few, if any, of even our best public libraries where complete sets of all that have been published can be found.

The results of these surveys are here extracted with great care and patience from a mass of matter on other subjects than coal, much of it of a technical character, or only of local interest, and arranged in a systematic and methodical manner. In order to produce an impartial and authentic history of the coal-regions of all the States, the descriptions of them given by their own authorities are generally reproduced, as nearly as the necessary condensation and change of form would admit; these official materials being to the history of the rocks what the dispatches of the general and the diplomatist are to the history of nations. Many additional facts are also given, the results of more recent observations of many other writers, or picked up in the course of sixteen years of active employment in a large coal-business, and in visiting many of the more important coal-regions. But a book of this kind, containing only the observations of any individual, however extensive his knowledge, would be of very little value. On the contrary, this is intended to be a sort of encyclopædia of all that is known on the subject, that is permanently important and valuable, as ascertained by many competent persons in all parts of our country. While our scientific men are absorbed in original investigations, others may do a good work by collecting and arranging in a new form for popular use the materials they furnish on special subjects like this. It is evident, however, that this book is more the work of a coal-merchant than of a professional geologist, and it has reference throughout to practical and useful results. By thus collating the accounts of all our great coal-fields in one view, we cannot but observe the regularity of the laws or system on which Nature has formed them, and we also get a comprehensive idea of the physical force of our country, accumulated for the use of

man among the strata of the earth. This collection of coal statistics will serve, therefore, not only to gratify curiosity, but also to exhibit, it is hoped not in an exaggerated or too flattering a form, our national wealth or resources in our supply of fuel.

Among the other more obvious reflections which will occur to those who may take an interest in the kind of information here given, will be the magnitude of our coal-fields, which in that respect are without a parallel in the world, containing in all 192,000 square miles, besides the lignites of the Far West; the vast quantity, the great variety, and the wide distribution of our stores of coal; their accessibility for mining purposes, in being so near the surface;[1] the facilities afforded for their cheap transportation to long distances; also the want of coal in other very extensive districts of our country, and the important questions connected with their supply. It will be noticed, too, that, while the exhaustion of the English coal-fields is being discussed, how little has really been done here in the way of mining our coal, and how powerless is all this fuel in the absence of population with intelligence, energy, industry, and the necessary capital, guided by science. Among the important advantages of our coal-fields are those of a climate where severe labor can be endured, where fuel is most in demand; and that of a Government strong enough to protect our rights, and wise enough to permit the best development of our own natural resources.

To American readers it is quite superfluous to refer also to that glowing picture of the future which we are all so much accustomed to draw for ourselves, or to speak of what we will do, and what we will make of all that is around us, with the aid of the latent power in reserve in our coal-fields. This work is confined to facts and contains but few reflections, but it furnishes abundant food for thought to the philosopher and the statesman. We seem to have before us a long period of

[1] All the coal being within mineable depths.

peace. The material prosperity of the country will hereafter engross the attention and efforts of our people, and constitute an important part of our history. The coal-regions of America are, therefore, a subject of national importance, and worthy of the attention of every well-informed person.

For the benefit of those who have but little knowledge of geology, some general information, applicable to all the coal-regions, is given in the Appendix on the origin and place among the rocks of coal-beds. This, as well as Chapter VI. on the characteristics of coal-seams, should properly be read by non-geological readers before the accounts of the coal-regions. A chapter on the conditions of success in the coal-trade, one on the combustion of coal, and one on the iron-ores of the coal-measures, with the latest statistics of the coal mined in the United States, and in foreign countries, are also added at the close of the volume. Some of these statistics are later than those given in the text.

Prof. J. S. Newberry has furnished the best portions of the chapter on Ohio, particularly the section of the coal-strata, in advance of his final report, and has added kind words of encouragement during the progress of this work. Profs. Cox, of Indiana, Worthen, of Illinois, and White, of Iowa, have all furnished useful statistics and information not contained in their published reports of the geology of those States. The recent geological surveys in those four great coal-producing States render this a suitable time for a publication like this. Dr. J. W. Foster has, with the concurrence of Messrs. Griggs & Co., the publishers of his "Mississippi Valley, its Physical Geography," etc., allowed the use of his "Geological Sketch of the United States," given on page 2. Acknowledgments are also due to numerous railroad officials and other gentlemen who have responded to inquiries for information as to the geology and coal-trade of various parts of the country.

If any of the scientific gentlemen, whose work has con-

tributed to this piece of mosaic, feel aggrieved by any want of due credit, or any erroneous statements, they will please attribute it to the difficulties of such a task as this, performed amid the cares of business, and not to any wrong intention. Corrections of any errors found in the work, which, in such a mass of facts and statistics on a subject of this character, and in a country so little developed as ours, must unavoidably occur, and further information as to any of the coal-regions, are respectfully solicited.

All coal, both anthracite and bituminous, carried to tide-water, is sold by gross tons (2,240 lbs.). West of tide-water, net tons (2,000 lbs.) are customary. The United States census reports are in gross tons for all parts of the country. The statistics in this work conform to the above.

J. M.

TOWANDA, PA., *March*, 1873.

PREFACE TO THIS EDITION.

THE present edition embodies numerous corrections suggested by several of the State geologists and others; also a supplement containing information collected since the publication of the previous edition, including the statistics of coal mined during the last year.

J. M.

TABLE OF CONTENTS.

TRIASSIC COAL.

CRETACEOUS COAL.

APPENDIX.

LIST OF MAPS.

LIST OF ILLUSTRATIONS.

THE IMPORTANCE OF COAL.

"Of other bulky articles in which commerce is carried on, manufacturing industry commonly returns to us some part of the identical substance which it had received as a raw material, something visible and tangible of which our senses can still take cognizance, which arrests our attention, recalling our minds to the original condition of those materials by which our wants are supplied or our senses gratified. On the contrary, the material which furnishes motive power is either wholly overlooked or soon forgotten. The evanescent movement of machinery which transports materials from place to place, or transforms them from one shape to another, leaves nothing visible or tangible on which our senses can dwell. We see around us the fabrics which were ordered from Manchester a short month ago, and we handle the yellow bars and dust which left San Francisco within the last forty days" (A. D. 1849); "but of the miraculous power which has winged their way hither we see no traces on the surface, and are prone to forget the useful labor of the black masses by which we are so largely benefited. A piratical act has been committed, or a hostile invasion is attempted or intended, and the arm of our national power is stretched forth to thwart the designs of wicked men; but, without the aid of this dark, forbidding mineral, the interposition of that arm would be all too tardy, its efforts altogether unavailing."—Walter R. Johnson.

"Coal," says Prof. J. S. Newberry, "is entitled to be considered as the mainspring of our civilization. By the power developed in its combustion all the wheels of industry are kept in motion, commerce is carried with rapidity and certainty over all portions of the earth's surface, the useful metals are brought from the deep caves in which they have hidden themselves, and are purified and wrought to serve the purposes of man. By coal night is, in one sense, converted into day, winter into summer, and the life of man, measured by its fruits, greatly prolonged. Wealth, with all the comforts, the luxuries, and the triumphs it brings, is its gift. Though black, sooty, and often repulsive in its aspects, it is the embodiment of a power more potent than that attributed to the genii in Oriental tales. Its possession is, therefore, the highest material boon that can be craved by a community or nation.

"Coal is also not without its poetry. It has been formed under the stimulus of the sunshine of long-past ages, and the light and power it holds are nothing else than such sunshine stored in this black casket to wait the coming and serve the purposes of man. In the process of its formation it composed the tissues of those strange trees that lifted their scaled trunks and waved their feathery foliage over the marshy shores of the carboniferous continent where not only no man was, but gigantic salamanders and mail-clad fishes were the monarchs of the animated world."

Coal is to the world of industry what the sun is to the natural world, the great source of light and heat with their innumerable benefits. It is not only the principal generator of steam, but steam is also dependent on iron, and the manufacture of iron on coal: therefore, these three most powerful among the physical agents of modern advancement have their source and basis in the coal-mine. Here, then, in these dark and gloomy caverns, and their coarse and rude productions, is a good subject for thought; and on a cold winter's evening when we enjoy the pleasant warmth of a fine coal-fire, while our apartments are illuminated by the gas from coal, we should endeavor to have intelligent ideas of the sources from which, and the means by which, these and so many other great comforts are derived; and, above all, we should see another instance of the wisdom and goodness of Him who hath in so wonderful a manner placed beneath our feet in exhaustless quantities and in an imperishable form the "stored-up fuel of a world."

THE COAL-REGIONS OF AMERICA.

I.

A PRELIMINARY GENERAL SURVEY.

Of the thirty-seven States composing the United States of America in 1874, the following contain no coal whatever of any kind, viz.: Maine, New Hampshire, Vermont, Connecticut, New York, New Jersey, Delaware, South Carolina, Florida, Mississippi, Louisiana, Wisconsin, and Minnesota. Several others, not named above, nominally contain coal, but it is of no commercial value. Among these are Massachusetts and Rhode Island, where a hard, worthless kind of anthracite is found. North Carolina has two small coal-fields of Triassic age, a later formation than the Carboniferous, but they are far in the interior, not at all productive, and will probably never be of more than local importance. The State of Virginia has, near Richmond, a field of coal, of the same age as those of North Carolina, which was once the most productive and important in the country, but it has long since lost its place in the coal-market. Georgia has a small area of the coal-formation in the northwestern corner of the State, not entitling it, however, to be counted among the great coal-producing States. There are, therefore, very extensive districts in the United States destitute of coal, and many of them the most thickly populated and the largest consumers of fuel.[1] There are four great carboniferous coal-fields in the United States. The first and most important, in all respects, is called the Appalachian, or, more properly, the Alleghany, and is of continental dimensions, being 875 miles

[1] See Geological Map, on page 2.

in length, extending through important parts of seven States, in a northeast and southwest direction, from 30 to 180 miles wide, and producing a great variety of the best qualities of coal. It covers the western part of Pennsylvania, the eastern part of Ohio, the western corner of Maryland, nearly all of West Virginia, the eastern part of Kentucky; it crosses Tennessee, and ends in the central part of Alabama. It is quite remarkable, however, that several of the largest producing regions are mere outliers, or detached, island-like fields on the borders of this great coal-region. The northeastern fragments are the anthracite basins in the northeastern part of Pennsylvania, the smallest in area, but the most important and productive of all. Also, along the eastern borders of the field are the Blossburg, Clearfield, Broad Top (Pennsylvania), and Cumberland (Maryland) basins, and there are similar very productive detached basins on the northwest, on both sides of the line between Pennsylvania and Ohio. The Pittsburg and Westmoreland district produces the largest quantity of bituminous coal, but this appears to be, at present, the only very productive region in the main body of this great coal-territory.

The second coal-field occupies the central part of the State of Michigan, and, although spread over a large surface, it is in ferior in importance to all the others, having only a thin seam of coal of a poor quality.

The third great coal-field is of enormous dimensions, covering two-thirds of the large State of Illinois, the western part of Indiana, and the western part of Kentucky. The best coal from this field is found in Indiana, and, although none of the coal it produces, with this exception, is equal in quality to the best Pennsylvania coal, yet it affords a great abundance of very cheap and valuable fuel.

The same remark applies to the fourth coal-field, which covers the southwestern part of Iowa, the best portions being along the Des Moines River. It also extends southward over a large area in Northern Missouri and into the eastern part of Kansas, the seams of coal being generally thin in all these States. Although it runs into the southeastern counties of Nebraska, it is feared the coal, if there be any, is there too thin for mining. From Kansas it spreads southward into the Indian Territory--

how far is not known; but a coal-field, which is probably a portion of it, is found in the western part of Arkansas, on both sides of the river of that name; and there is another in Texas, at Fort Belknap, in the northwestern part of that State.

The only other carboniferous coal-fields in America, in addition to those enumerated, are those of Nova Scotia and New Brunswick, and the latter is of no practical importance.

Of the parts of these coal-fields contained in each of the States, a separate account will be found in this volume. But there are large portions of all of these vast regions which have been so imperfectly wrought, or even explored, that they at present only furnish subjects for speculation as to the extent of our undeveloped resources, and for conjectures as to the future greatness of our highly-favored country. They will, therefore, occupy much less of our attention than their great number of square miles would seem to require. If their present importance and productiveness only were considered, many of them might be entirely omitted. Pennsylvania is at present the great producer, and, speaking in a general way, may be said to supply the United States with coal. Maryland sends annually to tide-water a little more than 2,000,000 tons of coal; West Virginia about 250,000 tons; Ohio ships from Cleveland annually about 500,000 tons, besides a large home consumption. With these exceptions, and the supplying of St. Louis from Illinois, no other State sends any considerable quantity of coal to market, outside of its own boundaries. A few of them produce quite largely, for their home consumption, in localities too remote to be reached by Pennsylvania coal. Of these, Illinois has probably the largest production; that of Ohio is increasing rapidly, as is also that of Indiana. Pennsylvania mined, consumed, and sent to market, in 1871, about 24,000,000 tons of coal, of which 15,000,000 tons were anthracite and 9,000,000 tons were of the various kind of bituminous coal. This State, therefore, indisputably stands preëminent in respect to the production, as well as for the variety and unequalled quality of its coal.

None of the United States Territories, and none of the States on the Pacific coast, contain any coal of the Carboniferous age, but they afford an abundance of the kind of fossil fuel called

"lignite," which is of inferior heating-power, of a much later age, found in newer and geologically higher rocks, formed long after the great coal-fields of the Eastern States. This lignite, which is found in the earth like coal, and has its appearance and uses, and is, therefore, entitled to be called coal, occurs in greater or less quantities in all, or nearly all, the States and Territories between the Missouri River and the Pacific coast, which compose more than half of the territory belonging to the United States. The principal localities where it is now most in demand, and found of the best quality, are along the lines of the Union Pacific and Kansas Pacific Railroads, in the southern part of Wyoming and the northern part of Colorado Territories. It is also abundant on the Northern Pacific Railroad. There is a controversy among geologists as to whether its age is tertiary or cretaceous, and its quality is better than that of any of the lignites or coals of the same age in Europe or elsewhere. After completing the accounts of the four great carboniferous coal-fields, these cretaceous coals, or lignites, of the Far West in the Rocky-Mountain regions, and on the Pacific coast, which furnish a species of fuel so different in its character, and supplying a region of country so remote from the other, will be separately considered.

II.

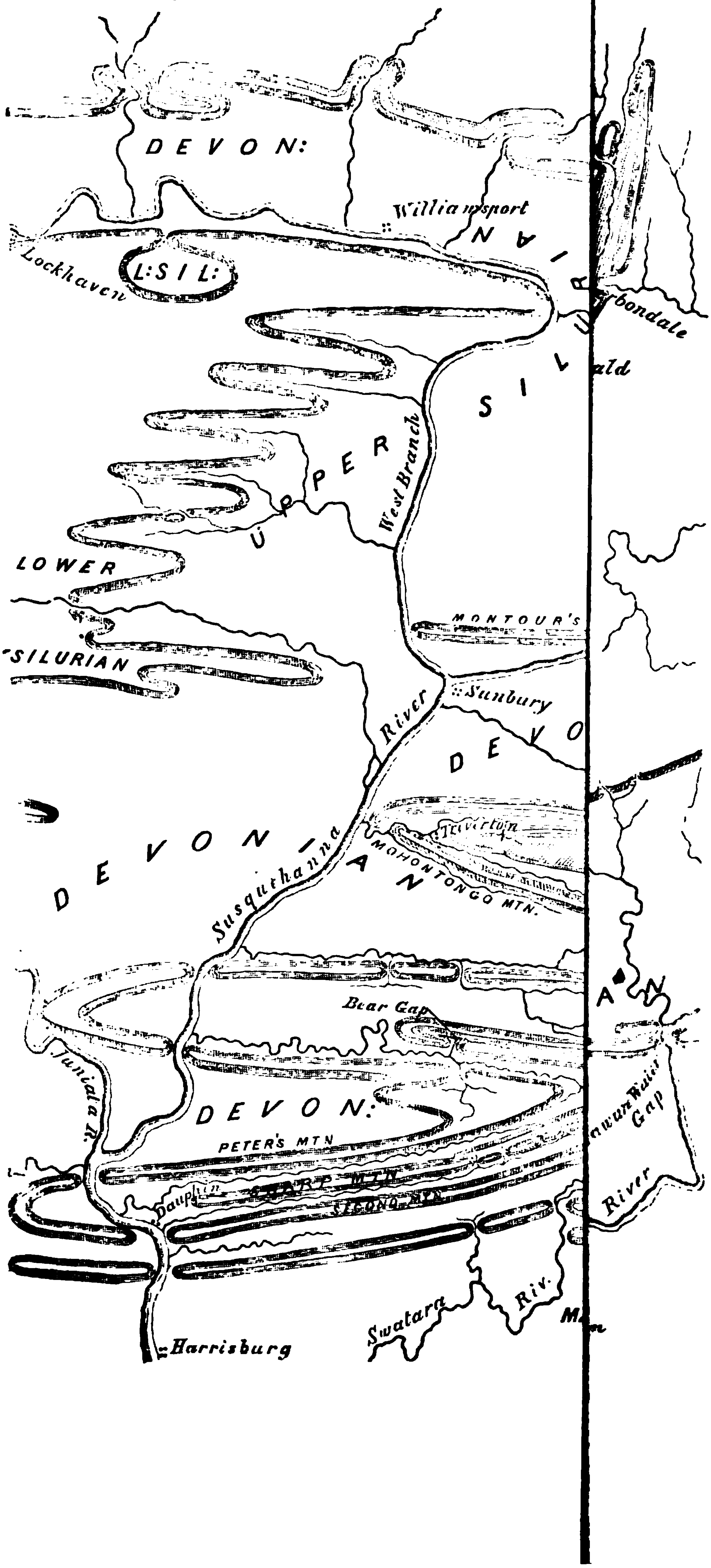
ANTHRACITE COAL-FIELDS OF PENNSYLVANIA.

The different kinds of coal in the United States might be divided into almost as many varieties as there are of trees in the forest; but, as it is here proposed to treat the subject in a matter-of-fact way, and in its commercial rather than its scientific aspects, it will answer our purposes to speak of them in general terms as anthracite, semi-bituminous, and bituminous, the first being situated farthest east in Pennsylvania, and the others extending northwestward in the order mentioned.

By far the most important and the best-known coal in this country is anthracite. It is the universal fuel for domestic use in the United States, in preference to all other kinds of coal, without much regard to their comparative cost, and it is also extensively used for other purposes. Every one knows it and uses it where it can be had; all feel more or less interested in it, and a very large portion of the coal-trade consists of it. Anthracite, or stone coal, is called glance, or blind coal, or culm, in England, and is the common hard coal of America. Its peculiarities consist in its being so largely composed of carbon, from 85 to 93 per cent., with less than 11 or 12 per cent. of volatile matter, which in fact is rarely found to amount to more than 7½ per cent., while its average quantity in our anthracite generally may be stated at about 6 per cent., and nearly the whole of this appears to be water. In the extreme west ends of the basins, however, a semi-anthracite is found, containing as much as 10 or 15 per cent. Anthracite has a specific gravity of from 1.39 to 1.61. In its structure it is massive and compact,

the softer varieties having a tendency to lamination. Its fracture is conchoidal in the hardest varieties only, but sometimes irregularly so; in other cases, with a tendency to columnar fracture. Its color is jet black, the hardest kinds metallic black, sometimes grayish black, and it almost always has a bright, glassy lustre, and occasionally a beautiful iridescent color. It is less easily kindled than other kinds of coal, and often decrepitates when kindling, and burns with but little flame. With an insufficient supply of oxygen in burning, it produces a short, blue flame, the product being then carbonic oxide; but when properly burnt it has great heating power, and leaves but little ashes, retaining its form, although the softer varieties break if burnt rapidly, but it never melts, swells, or forms coke. Its hardness is an invaluable quality, enabling it to be transported to any distance without injury from handling or exposure, although it is attended with some waste from breakage. It does not soil the hands, and, from its cleanliness, the absence of smoke, soot, and dirt, it is universally preferred for domestic use. Without exaggeration, it may be said that, as a house-coal, the world can produce nothing to compete with it at the same price. All those who have been accustomed to its use, pronounce it the perfection of domestic fuel.

Although there is a formation containing anthracite coal in Rhode Island and Massachusetts, that is a better subject for the studies of the geologist than for the labors of the miner, being of so hard and inferior a quality as to be unfit for use, or found in a form so unfavorable for working that it is not mined or sent to market. The marketable coal from the other States is all bituminous; therefore Pennsylvania possesses a monopoly of this most valuable article, anthracite coal. "The exclusive ownership of this important and popular species of fuel in large quantities within short distances of the seaboard," says R. C. Taylor, "is a possession of inestimable value, and places Pennsylvania in an enviable position. It is difficult to say what number of population its production alone will hereafter sustain, or to what degree of power and importance it may ultimately elevate this State." Many years ago Prof. Silliman called it a great national trust. The peculiar and valuable qualities of this coal, the very large quantities produced finding


DEVON:
Williamsport
Lockhaven
L:S I L:
UPPER
SILU
West Branch
LOWER
SILURIAN
MONTOUR'S
Sunbury
River
DEVO
DEVONIAN
Susquehanna
MOHONTONGO MTN.
Bear Gap
DEVON:
PETER'S MTN
Juniata R.
Dauphin
SECOND MTN
Gap
River
Swatara
Riv.
Harrisburg

a market over a very extensive territory, the very small region of country in which only it is found, the great number and size of the beds, the extraordinary form in which they lie in the ground, and the no less extraordinary character of this wild, barren, mountainous coal-region, make it the most interesting, curious, and important of them all.

Location and Extent of the Anthracite Regions.—The North Branch of the Susquehanna River, sometimes called the East Branch, one of the most striking features on the map of Pennsylvania, is formed by the junction of the Chemung and Susquehanna, in Bradford County, just within the northern boundary of the State. Thence it pursues a southeast course for about 100 miles to Pittston, cutting a valley about 500 to 1,000 feet deep, first through the Chemung group, and farther south through the Old Red Sandstone or Catskill group, the dip of the formations being toward the south. There is no coal whatever in the part of the State northeast of this portion of the river; but at Pittston the river strikes the inside centre of the third or Wyoming and Lackawanna coal-field, which lies in a northeast and southwest direction, in the form of the moon in her first quarter, with the convex side toward Philadelphia, and the upper horn pointing toward the northeast corner of the State. The Lackawanna Valley coal-region is northeast, and the Wyoming Valley coal-region is southwest of Pittston, both being parts of one uniform and symmetrically-formed basin, only distinguished by the streams by which they are drained.

The Lackawanna River, an inconsiderable stream, rises not far from the northern line of the State, in the highlands, between Susquehanna and Wayne Counties, thence running southward, it breaks into the coal-field at its northeastern extremity, where the coal-measures are considerably elevated, as they are also at the southwest end of the basin; and, passing through the centre of this northeastern half of the field, which is called the Lackawanna region, it unites with the Susquehanna, where it breaks through the northern boundary of the coal-basin at Pittston, about ten miles above Wilksbarre. The main river then makes a right angle and pursues a winding course through the middle of Wyoming Valley, the coal-seams being hundreds of feet below the bed of the river, and passes lengthwise

through the coal-field to Nanticoke, a distance of 15 miles from Pittston. It here, curiously enough, passes out of the coal-field to the north, breaking through the mountain-barrier which bounds the basin, and then severing the mountain lengthwise by resuming its former course for eight miles outside of the coal-basin to the mouth of Shickshinny Creek. It there again turns to the south, again enters the coal-field, and, running across it, passes through the southern boundary, leaving undisturbed the southwestern end or point of the coal-deposit, 200 feet above and west of the river. The river thence pursues a southwesterly course to Northumberland, where it unites with the West Branch, and then runs nearly due south to Harrisburg. The Susquehanna, as above described, may be considered as the dividing line between the anthracite and bituminous coal, excepting only a small portion of the field, from Pittston to Nanticoke, extends about one or two miles in width across it to the west side. This Lackawanna and Wyoming Valley is the location of the third coal-field. Proceeding southward to the second coal-field, our attention is directed to the Lehigh River, an important branch of the Delaware, which, from its head-waters, east of the Wyoming region to Mauch Chunk, forms another of the obvious natural boundaries of these coal-regions. All the hard anthracite coal in the United States, and, practically speaking, in the world, comes from this small central part of the eastern portion of Pennsylvania, east of the North Branch of the Susquehanna, and west of the Lehigh River. The north horn of the Lackawanna coal district, however, extends much farther north than the sources of the Lehigh. Neither the Lehigh, the Susquehanna, nor the Schuylkill, is navigable. A map showing the whole of the anthracite coal-fields would include a long, irregularly-shaped tract, extending in a northeast and southwest direction between the Lehigh and Susquehanna, 100 miles in length and 30 miles in breadth at its widest part, in which the coal formation proper, consisting of scattered fields and basins, would constitute but a small part of this area. The coal is found in at least twelve or more detached and separate fields, of a basin-form; three of them (the Mahanoy and Shamokin being considered as one) are large, and the others are much smaller.

They are irregular in their outlines, and contain coal in an extraordinary number of seams and beds, some of them of an astonishing thickness. The great number and size of the seams, and the form in which they are found among the rocks, constitute as marked a distinction between these regions and the bituminous, as there is in the appearance and characteristics of the coal produced in each region.

As there are some errors prevailing in regard to the geography or topography of this part of Pennsylvania, it may not be amiss to state that the anthracite regions, although in a mountainous country, are not on the Alleghany Mountain. The southeastern margin of that important range of mountains runs nearly parallel with the Lackawanna and Wyoming coal-field, but northwest of it, and crosses the North Branch of the Susquehanna, between Pittston and Tunkhannock, and the first of the six great coal-troughs of the Alleghany field occurs on Mahoopeny Creek, in Sullivan County, where a soft, free-burning semi-anthracite is produced.

The mountains of the anthracite regions, on the contrary, are a continuation of the Catskill Mountain, which every traveller on the Hudson River sees between New York and Albany. From that locality it runs to Mauch Chunk, Pennsylvania, being composed of a geological formation below the coal, which is remarkable for its great thickness and the rapidity with which it thins out and disappears altogether in a western direction, extending but little more than half-way across New York, and in great thickness only over the eastern part of Pennsylvania. The upper of its three members nearly runs out, and the other two in diminished size run under the Alleghany Mountain coal-basins. This great Catskill Mountain forms the foundation of the anthracite regions, and in Pennsylvania geology it is divided into three parts, called the Ponent red sandstone, Vespertine sandstone, or conglomerate, and Umbral red shale, or two great red shales with a white sandstone between them, and over all lies the conglomerate base of the coal-rocks. The Vespertine and Umbral are subcarboniferous.

Taking a general view of these mountains, we find the portion of them where the coal-fields are situated has only three broad or flat-topped mountains, according to Prof. Lesley's

topography,[1] viz., "the Broad Mountain, five miles wide and 15 long, which separates the Pottsville and Mahanoy basins; the Beaver Meadow Mountain, eight miles wide and 15 or 20 long, on the top of which lie side by side the numerous little but important Lehigh coal-basins; and the Nescopeck Mountain, between the second and third coal-fields, which is crossed by the Lehigh Valley Railroad, and merges itself eastward into the great Pocono table-land. With these three exceptions, the mountains of this region are all sharp, rocky-sided ridges, or walls of steeply-inclined strata of sandstone, surrounding the several coal-basins in beautifully symmetrical curves."

For the sake of convenience, these anthracite regions are now usually divided into three coal-fields or districts. The first, southern, or Schuylkill coal-field, is one continuous, unbroken basin, except the detached field of Mine Hill. The second district includes the Shamokin, the Mahanoy, and the Lehigh basins, embracing all the other small fields and basins. The third is the large, unbroken northern or Lackawanna and Wyoming region. A general preliminary view of each is first necessary. The first or Schuylkill coal-field may be considered as forming a long, narrow trough or basin, enclosed by a continuous mountain, called the Locust and Broad Mountain on the north, and the Sharp Mountain on the south. Nature has made several deep cuts in these mountain-barriers down to the bottom of the valley, through which various streams pass, forming the drainage of the country, affording also very convenient locations for railroads to carry the coal to market. The most important of these, on the south side, are the Little Schuykill, at Tamaqua; the Schuylkill River, at Pottsville; the West Branch of the same, at Minersville; and the Swatara Creek, at Pine Grove. Farther west are the Wiconisco and Stony Creeks. On the north side are Leggett's Gap, and three or four others. In approaching this coal-field from Philadelphia by the Philadelphia & Reading Railroad, the great system of double mountains and valleys, which everywhere encircles the coal-basins, is seen in all its magnitude, in fine natural sections at the several gaps through which the rivers and railroads find their way.

[1] "New Topographical Atlas of the State of Pennsylvania, with Descriptions," etc. By Henry F. Walling and O. W. Gray. Philadelphia, 1872.

The second coal-field, including the Shamokin, Mahanoy, and Lehigh basins, occupies the summit or highest ground between the waters of the Schuylkill on the south, the Lehigh on the east, and the Susquehanna on the west, in the midst of a dense chain of mountains extending across the entire country between the two last-named rivers. It lies at an average distance of ten miles north of the first coal-field, and nearly parallel to it. It is also, like the others, enclosed or bounded by a continuous range of double mountain-barriers, commencing about three miles west of the Lehigh, and ending in the forks of the Mahanoy Creek, in Northumberland County, about five miles east of the Susquehanna. On the south, these ridges are called the Spring, Mahanoy, and Locust Mountains. On the north, parts of them are called the Shamokin, Catawissa, McCauley, and Green Mountains. There are also numerous other anticlinal axes within these general boundaries which subdivide the district into the several important smaller basins of which it is composed. There are many different local names for all the mountains, and for different parts of the same mountain.

The third, northern, or Wyoming and Lackawanna, is the largest and finest of the anthracite coal-basins, and is the only portion having any pretensions to beauty. It reposes in the bosom of the beautiful valley, as before mentioned, in the form of a long and very narrow, perfectly-shaped crescent or slightly-bended bow, the eastern or northeastern horn extending beyond Carbondale, and the southwestern extending just across a bend of the Susquehanna River, at Shickshinny. It is a solid, unbroken field of more than 50 miles in length, while its greatest breadth is 5 miles and its mean breadth 3½ or 4 miles, and it contains 198 square miles. It is situated wholly in the county of Luzerne, and is completely shut in by mountain-barriers called the Shawnee Mountain on the north, and the Wyoming Mountain on the south, the only natural outlets being at the points where the Susquehanna River enters and leaves the valley, cutting the bounding-ridges to their base. Numerous railroads, however, find their way over the mountains, to carry the coal to the Eastern and Northern markets. The coal-seams have the basin-form which the surface presents, and conform to the undulations, which are not unfrequent.

They do not rise, however, to the summits of the mountains, but only to a moderate height up the slopes. They extend to an unknown depth below the bed of the river in the central portions of the basin, several hundred feet below the level of the sea, and are contracted in width and elevated at both extremities, just as if the strata had been first formed in an horizontal position, and Nature had then made an effort to fold them together like a vast volume with a conglomerate binding, and had only been partially successful.

From the foregoing descriptions, it will have been observed that the basin or oblong trough-shape of these anthracite coal-fields applies to their external appearance as well as to the geological structure of the coal-seams. The height of the bounding ridges or margins of all the larger coal-basins may be stated, in a general way, as not less than from 1,000 to 2,000 feet in elevation above the valleys or lower portion of the troughs; and, all the basins being formed on the same general pattern, the coal-seams always have a tendency to rise toward the extremities of the basins, where the outer walls come together and pinch out the coal. The lowest places on the mountains are selected for the passage of railroads, where no natural gaps are found. Of these railroad summits on Wyoming Mountain, on the south side of the third coal-basin, that of the Lehigh and Susquehanna, which is the lowest, is 1,092 feet above Wilkesbarre, and the latter place is 538 feet above tide-water. In regard to the mountain boundaries of all these basins, it should be noticed that, if we extend our view beyond their immediate margins, we find a second and higher range of sandstone mountains, separated from the first by a red-shale valley, and they have been appropriately called the double frame of the coal-basins. The upper or inside one is the conglomerate base of the coal-measures, the second formation is a red-shale valley named by Rogers the Umbral red shale, and the third is the second mountain, and is his Vespertine sandstone. Next is his Ponent red sandstone, the last three being the equivalent of the Catskill, and outside of all occur the Chemung and other well-known formations. These Umbral and Vespertine rocks correspond in position with the subcarboniferous limestones of the Western States. Some coal-fossils are

found in them, and they are therefore subcarboniferous in a geological sense, but worthless as regards the production of coal. On the north side of the Lackawanna end of the third coal-field alone, the red shale being thin, the two mountains are pressed together, forming here but one mountain. All the anthracite regions, except Wyoming and part of the Lackawanna Valley, and all the extensive intermediate country, are too sterile to be cultivated.

The total area of all the anthracite coal-basins is as follows:

	Square Miles.
1. Southern or Schuylkill Basin and Mine Hill	146
2. Shamokin, 50; Mahanoy, 41; and Lehigh Basins, 37	128
3. Wyoming and Lackawanna Basin	198
Total area of all the anthracite basins	472[1]

It is sometimes difficult to make people believe that all the anthracite or common hard coal of America, which is used everywhere, of which more than 19,000,000 tons are annually mined, and which is sent for use almost all over the Western World, really all comes from this one small locality in Eastern Pennsylvania. If these regions were all brought together into one body, they would only form a small county, twenty miles wide and a little less than twenty-four miles long. This area appears insignificant when compared with the vast dimensions of some of the bituminous coal-fields to be described. But, when we come to inquire into the number and thickness of the coal-seams, if we were to calculate the quantity of coal per acre, examine into the relative quality of the coals as to their commercial value, and look at the tonnage of each region, we shall see that the number of square miles covered by the coal-measures is of very little importance, unless viewed with reference to the workable thickness of coal and the other circumstances mentioned.

The wide distribution of coal on the North-American Continent is of most importance to the country on account of the fuel being thus found in the localities where it will be needed, and many of which could not be supplied with good coal at a reasonable cost from any great distance, from the want of cheap water transportation. In this aspect it is of more value to the country than in the tens of thousands of square miles of coal

[1] By P. W. Sheafer's Surveys.

area. But we must not be deceived by large figures; for, as the small islands of Great Britain are of more importance in every respect than vast, thinly-populated countries like Africa or South America, so this small anthracite region should be considered as compared with the immense thin sheets of bituminous coal, or still larger fields of very poor lignite, which make such a show on geological maps of the United States.

Formation of the Coal-Basins.

There is but little doubt that all the anthracite coal-fields are but the several portions of one great formation which, previous to assuming the present basin-form, constituted a single continuous body or mass of strata. This is evident from a careful comparison between the same parts of the series in each separate basin. The same conglomerate rock underlies all the basins, and, notwithstanding the irregular forms into which it is now thrown, it observes a regular and manifest diminution in the size of the pebbles of which it is composed, and in the thickness of the stratum, as we pass from the Sharp Mountain, on the southern side of the southern basin, to the middle and northern basins. In the former it is 1,400 feet thick at Tamaqua, and 1,031 feet at Pottsville, and at Pine Grove considerably less; and in some localities some of the pebbles are of the size of an orange and larger. Farther north the materials assume a smaller and more uniform size, and the entire mass becomes homogeneous, passing into a nearly pure quartzose conglomerate. At Girardsville it does not exceed 800 feet, at Shamokin Gap 700 feet, at Nanticoke about 300 feet, and at the west end of the same valley, at Beech Grove, about 200 feet is its total thickness. This is evidence to prove that it was all formed in one connected and continuous stratum. A sedimentary rock, too, could not have been formed with the steep dips of some of these coal-basins.

Another strong point of resemblance is in the series of coal-seams and their accompanying strata. There is one great coal-seam which lies near the base of the coal-measures, commonly the fourth above the conglomerate, and there is but one of this magnitude. It occurs in each of the basins, and in the same part of the series, with its neighboring strata bearing a close

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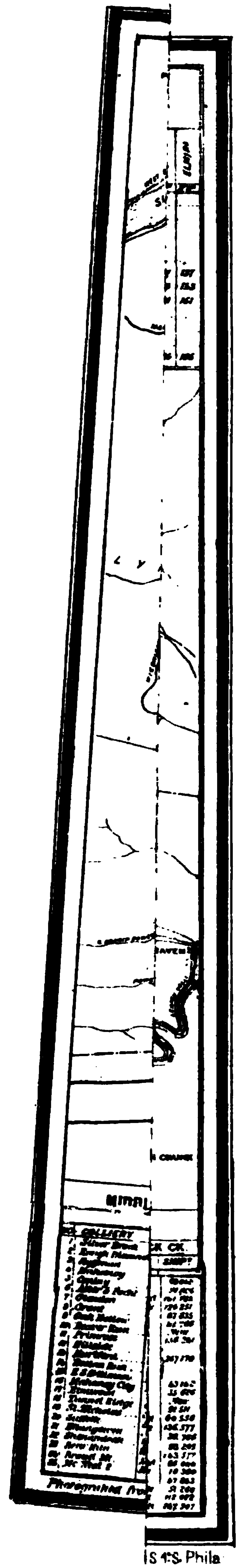
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resemblance in each, with an exact identity in the vegetable fossils of the slates. This, with the want of identity with those in the higher portion of the series, furnishes ground for the belief that, where this Mammoth seam, as it is called, occurs, it is but a remaining part of an originally more widely-diffused deposit belonging to all the basins. This great seam also decreases in thickness in going northward, being 50 feet thick at Summit Hill, 28 feet at Pottsville, 24 feet at Beaver Meadow and Hazelton, the same at Wilkesbarre, and 14 at Pittston. It also diminishes in going from east to west.[1] There is also a general resemblance in the series of coal-seams of the lower coal-measures and their intervals of rocky strata, where they occur in all the basins, making proper allowances for the progressive changes always discernible in strata when traced over extensive areas.

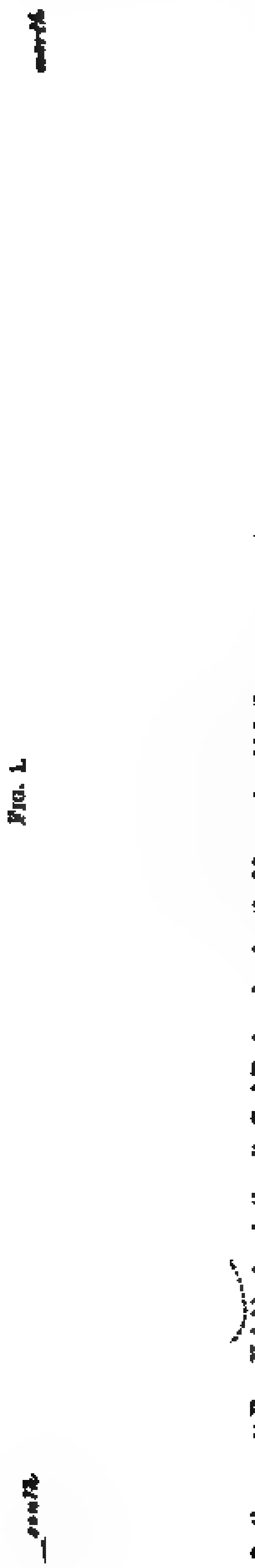
The usual shape and structure of all the several great anthracite tracts of this State are those of long and irregular basins. They have doubtless assumed this form from the elevation, on all sides of them, of the underlying rocks of the country in a series of nearly parallel belts, from which the strata dip in opposite directions, or, as they are technically called, anticlinal axes. The coal-strata are now found only in the intermediate spaces between the lines of upheaval, in these basins or troughs, the strata dipping from both margins inward, sometimes at a high angle, caused by the tilting upward of the underlying formations, and the destruction, by the action of water, of the broken portions of the coal-strata which once covered the upheaved intervals, between the basins which, consequently, are now barren of coal. These two grand causes, subterranean elevation, and superficial denudation by water, fixed the limits and produced the form, and the singular positions and disturbances of the anthracite coal-regions.

In addition to this violent upheaving action of the strata outside of or around the coal-basins, enormous parallel wrin-

[1] The statistics and more valuable ideas in regard to the geology of both the anthracite and bituminous coal-fields of Pennsylvania, where not otherwise credited, are derived from H. D. Rogers's final report of the "State Geological Survey," 1858 (D. Van Nostrand & Co., New York), and his six annual pamphlet reports of progress from the years 1836 to 1842. A full note on this work, with the names of all Prof. Rogers's assistants, will be found at the close of the chapters on Pennsylvania.

klings of the coal-measures themselves have taken place within the coal-basins, causing great intricacy in the internal structure of many parts of these regions. There are also great dislocations of the strata, the results of the same subterranean movements. A general idea of the structure of the region is sufficient for the reader, who will understand that these lines of upheaval were between where the several coal-basins now are found, and that the bodies of coal which were preserved for our use are those found in the deepest portion of the basins, and that the deeper the basin the larger is the number of coal-seams.

FIG. 1.



Section across Four Neighboring Anthracite Coal-Basins, showing the Manner in which they are separated from each other by the Lower Rocks rising between them and forming Anticlinal Axes.

But, another explanation seems necessary to those who have not seen, or studied the geology of this wonderful region, namely: that the anticlinal or upheaved mountains are entirely removed over many extensive localities, and that where, if an upheaval only had occurred, a very high mountain of broken coal-measures would have existed, we now, as a general rule, find deep valleys cut down into the formations below the carboniferous rocks, even the heavy strata of conglomerate which underlaid the coal being entirely swept away, with not a vestige of these great formations to be seen, and in their place are red-shale valleys which were, originally, thousands of feet below their present level. The coal-basins are but fragments of a far greater formation, and the underlying formations are in an equally fragmentary condition, with enough of each remaining to show the remarkable structure of the region. It is certainly difficult even to imagine what has become of the vast mountains which have been removed and cast into the midst of the sea.

To a visitor, nothing is more surprising than the high steep ridges which traverse the interior of the Schuylkill, Shamokin, and Mahanoy coal-fields. The usual description of them as basins or troughs, bounded by mountains, prepares him for altogether a different-looking country from the one he finds. They are, in fact, valleys filled, wherever they are wide enough to admit of it, with long hills running east and west, with slopes often of great steepness, and these hills or ridges are of very considerable height, sometimes rivalling in elevation the outside or boundary mountains. The entire coal-fields are filled with them: those in the first, or Schuylkill basin, are very irregular in their length and position; those in the second coal-field are more regular; while those of the third or Wyoming field have assumed some system, as will be hereafter described. There is an evident gradation in the degree of force spent in producing them, which has become less as you go northwestward. This is especially observable in the third field, so that, when we go to the Lackawanna end of it, we see a much more uniformly-shaped trough or curving valley with comparatively few undulations, contrasting strongly with the Sharp Mountain west of Pottsville, which is thrown over toward the coal-basin past the perpendicular.

The Form of Anthracite Coal-Seams.

To understand the extraordinary form in which the anthracite coal-seams are disposed, we must, therefore, not only imagine the general structure of these troughs, or rather canoe-shaped basins, with their sharp, elevated ends, a feature which applies to all of them, but we must also bear in mind the corrugations or wrinkles which sometimes attain to great size, and which characterize the interior portions of each basin, particularly the large and more southern coal-fields. The general course of these folds and flexures of the strata is east and west, or, as we pass from south to north, we would generally run across these waves, and, in going east and west, we would traverse the bottom of the troughs or synclinals, or the crests of the folds or wrinkles, called anticlinals in mining phrase.

The series of strata consists of numerous noble seams of coal, from 6 to 50 feet in thickness, with other smaller ones, of which

no notice is taken. These coal-seams, with fire-clay floors and black-shale roofs, are separated by alternate layers of sandstone and sometimes shales from 10 to 500 feet thick, each coal-seam and each layer of sandstone corrugated and folded alike. "Thus, each sheet of coal extends for itself, and by itself, as far as the valley does in which it lies, cleaving down through the mountain from summit to base, from end to end, passing under the adjoining valley, and reascending through the length and breadth of the mountain on the other side. Each coal-bed does this independent of each other, while conforming to each other's motions, but never coming into conflict, or even actual contact, however near, except in faults."[1] In Rogers's State Geological Report, a large quarto volume is nearly filled with details as to the coal-seams and minute descriptions of the numerous flexures of the anthracite formations as they were then known, with their saddle-like upheavals or anticlinal axes, and their trough-like down-throws or synclinal axes. Daddow and Bannan, in "Coal, Iron, and Oil," have also put on record later accounts of these, the knowledge of which is indispensable to anthracite-coal operators, but to enumerate them would be tedious and very uninteresting to the general reader. In the Lackawanna region, and the more northern parts of the Wyoming Valley, these flexures do not occur in such great size, the seams of coal are more regularly disposed in a general uniform basin more nearly approaching the horizontal form of bituminous coal-seams, and affording opportunity for more simple methods of mining.

Number and Size of the Coal-Seams.

In the anthracite coal-regions of Pennsylvania we find this valuable substance in an abundance, for the amount of surface occupied, not surpassed in any part of the world. At Pottsville, in the deepest portion of the first coal-field, all the seams are supposed to be fully represented, although some of them attain to greater size in other parts of the regions. The reader, with the least imagination, can perceive that, with the basin-shape of these coal-fields, a shallow basin cannot contain as numerous seams of coal as a deep one, the thickness of the intermediate

[1] "Manual of Coal and its Topography," etc., by J. P. Lesley, Topographical Geologist. Philadelphia: J. B. Lippincott & Co., 1856. 12mo, pp. 224. (Out of Print.)

rocks being the same. But it appears like one of the compensating and equalizing provisions of Nature that the numerous coal-seams in the deep basins are thinner than the fewer beds in the shallow basins, which are much larger. The depth of the basins, however, depends on the power of the compressing forces which formed them. The thickness of the coal-seams is owing to the local distribution of the vegetable material of which the coal was formed. In practice, it is the one or two larger seams that are all-important. In this country, the best coal, and the cheapest to mine, is first taken. Where the Mammoth bed is found 14, 20, 25, or 30 feet thick, all the coal is mined in that alone, even if in doing so all the smaller seams should be destroyed, on the principle that it affords an abundance of coal for our day, and future generations can take care of themselves. As a general description, it might be said that, in the deepest part of the first or Schuylkill coal-field, there are 15 coal-seams, each from 3 to 25 feet, in all 113 feet in thickness, of which 80 feet is considered marketable coal. These seams extend to a considerable extent throughout the three fields or basins, so far as their depth admits of their existence, there being everywhere numerous separate beds, some of them compound strata of great size, which in other localities are separated, with many other smaller ones of ample size for profitable working.

Taking the several anthracite districts in a general view, Prof. Rogers reports that the first coal-field possesses an average thickness of 100 feet of coal, and the second and third would measure about 60 feet, and the general average of all the regions together would be about 70 feet, and the separating strata of rock between the several coal-seams vary from 10 to 500 feet thick. The formations are of too irregular a character, however, to admit of any very accurate general statement of this kind, and mining-engineers differ very much in their estimates of the total quantity of anthracite coal in all the regions. But all agree that the quantity is large, and that the waste in mining, and in the process of breaking, by which the coal is prepared for market, is enormous.

On page 23 is Daddow and Bannan's table of the names and thickness of the anthracite seams in the Pottsville district, beginning with the lowest.

The annexed section of the coal-strata at Pottsville has been kindly loaned by Messrs. Daddow & Bannan, from their valuable work, "Coal, Iron, and Oil." A, the lowest seam, is not valuable or workable. B, or the Buck Mountain, is a very important bed, 25 to 30 feet thick, at Plymouth, and in some of the Lehigh basins. The third seam, C, is not usually workable, except in the small New Boston basin and in the Mahanoy region. D, the Skidmore or Wharton, is a good bed, 6 to 12 feet thick. E is the Mammoth, the largest and best of all the anthracite coal-beds, from 12 to 70 feet thick; but its best size is about 30 feet, as in the Lehigh basins, producing more coal than when at its maximum size. In parts of the Mahanoy basin it is 70 or 80 feet thick. Sometimes benches of coal occur in it 10 or 12 feet thick, without a marked parting of bone or slate (Daddow). In some localities it is divided, and an upper bed of seven feet is separated from it. This E bed corresponds with the upper bed of the lower bituminous coal-measures, F with the small seams in the barren measures, and G, or the Primrose, with H, or the Pittsburg and Cumberland bed, in the sections for Pennsylvania, Maryland, West Virginia, and Ohio, given on pages 211, 252–256, 277, and 318. The upper anthracite-beds, from H to N, or some of them, are represented by the Redstone, Sewickly, and Waynesburg beds, in the sections mentioned. In the Maryland section, page 252, seven coal-seams, large and small, occur above H, or the Big bed, of that region. The identity of the anthracite coal-beds with the bituminous throughout Pennsylvania, Ohio, Maryland, West Virginia, and Eastern Kentucky, may be considered as well established.

	Names.	Coal-Seams.		Coal-Measures.	
		Max.	Min.	Max.	Min.
A	Alpha..........	4	1	50	10
B	Buck Mountain..	30	6	75	35
C	Gamma........	8	2	150	40
D	Skidmore.......	12	4	150	40
E	Mammoth......	75	12	100	22
F	Holmes........	6	3	300	41
G	Primrose.......	16	6	150	44
H	Orchard........	8	4	150	92
I	Little Orchard...	4	2	100	21
J	Diamond.......	10	5	300	85
K	Tracy..........	12	6	250	150
L	Little Tracy.....	4	2	100	50
M	Gate...........	16	6	200	150
N	Sand Rock......	4	2	150	100
		205	60	2,175	820

A simple statement of the thickness of the coal-seams, measured at right angles, will not give a correct idea of the quantity of coal in a given area, as an horizontal seam of anthracite coal is unknown. Take, for example, the Nesquehoning or Rhume Run mines, in the eastern end of the first coal-field, where the seams are vertical; after descending to a great depth, they rise to the surface, and then descend and rise again, forming across the field, or in a north and south direction, three synclinals, or basins, with two anticlinals or saddles between them.[1] The sections of all parts of the anthracite regions present these waving and doubling lines and extraordinary undulations. The usual calculations of the number of square miles of coal multiplied by the thickness of the seams, and the product reduced to tons, are therefore of no value, unless we first bring these basins and saddles to an horizontal surface, and thus very greatly increase their area. On the other hand, we may very much exaggerate the quantity of workable coal; for, if we examine the quantity actually worked, we will observe that vast quantities of coal are wasted. Thus, at the Rhume Run mines, above mentioned, a line drawn across the numerous undulating seams of coal would measure 297 feet, of which 133 feet is workable coal, while but one of the numerous seams, called the Mammoth, is actually worked. There are localities where the force used, in throwing the coal-seams into their present vertical and wav-

[1] See plate on page 24

Fig. 9.

Vertical Section across Nesquehoning Coal-basin, near Mauch Chunk, Pennsylvania.

EXPLANATION.

1. Locust Mountain.
2. Sharp Mountain.
3. Anticlinal Axis No. 2 (R. P. Rothwell).
4. Anticlinal Axis No. 3 (R. P. Rothwell).
5. Anticlinal Axis No. 4 "
6. Synclinal Axis B "
7. Synclinal Axis C (R. P. Rothwell).
8. Synclinal Axis D "
9. Synclinal Axis E "
10. Panther Creek.
11. Summit Hill.
12. Old Quarry (coal).

1 to 2. Panther Creek Valley.

Coal-veins.

A. (Rogers), 4 feet.
B. " 5 feet.
C. } Small Veins of Coal.
D. }
E. (Rogers), Mammoth Vein, 25 feet.
F. " Red-ash or Funnell Vein, 15 feet.
G. (Rothwell), Brown Vein, 5 feet.
H. Small Upper Red-ash Veins.

a. Red Shale (ix.), Ponent (Rogers), Catskill Period of Devonian Age.
b. Sandstone (x.), Vespertine (Rogers), Lower Subcarboniferous of Carboniferous Age.
c. Red Shale (xi.), Umbral (Rogers), Upper " " " "
d. Conglomerate (xii.), Seral (Rogers), Millstone-grit Epoch " " "
e. Strata of Slate and Sandstone between Coal-beds, Coal-measures of " "

The section represents a depth of about two thousand feet. It shows two of the grand folds of the Appalachian system (1, 2), and three intermediate smaller ones (3, 4, 5).

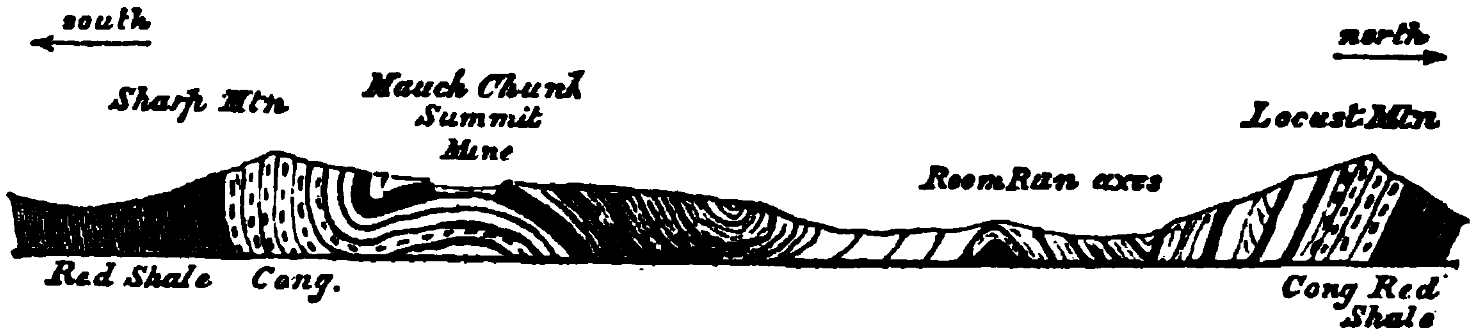
ing positions, has seriously injured the quality of the coal. But far greater than all is the waste in unmined coal, and of that which is mined, in preparing it for market. The foregoing tabular statement of the number, names, and thickness of the larger workable anthracite coal-seams, omitting numerous smaller ones, is well worthy of careful study by all who are interested in any of the coal-regions of America, as it is, in fact, the alphabet of all the coal-seams. The correlation of the Alleghany and Illinois coal-fields is doubted, but the identity of the seams throughout the whole Alleghany coal-region is becoming more evident as investigations are extended, and the characteristics of each seam, in localities where it has been well developed, serve to throw light upon what may be expected of it in other and even very distant places. The table which not only gives the maximum and minimum thickness of the coal-seams, but also of the coal-measures or rocks separating the coal-seams from each other, is from Daddow and Bannan's book, "Coal, Iron, and Oil," to which readers are referred for further details as to the characteristics of the different seams and numerous statistics and descriptions of these wonderful regions, with a treatise on mining, and descriptions of mining machinery.[1]

In examining this extraordinary display of mineral wealth, the eye is attracted by the Mammoth bed. Its great size, the superior quality of its coal, and its cheapness of mining, have attracted the miner also, so that three-fourths of all the coal sent to market is taken from this favorite bed, without much regard to true economy or the permanent value and future development of the property. It will be observed that there are many seams found from six to nine feet thick. A very fine seam is worked in the Wyoming Valley, of a thickness of 24 feet and upward, and in other regions are some much larger, one of the most remarkable of which was the old Summit Hill mine, of the Lehigh Coal & Navigation Company, where, for a long time, it was worked in an open quarry of 10 acres in extent, 70 feet in depth, owing to a doubling together of the strata, the seam being actually 55 feet thick measured at right angles, of which more than 40 feet was of the very best quality of coal.

[1] "Coal, Iron, and Oil; or, the Practical American Miner, a Plain and Popular Work on our Mines and Mineral Resources," etc. By S. H. Daddow and Benjamin Bannan, 1866. (Published and for sale by B. Bannan, Pottsville, Pa., 8vo., pp. 808.)

In all, 850,000 tons of coal were thus taken out, so that every available acre of land produced 85,000 tons of excellent coal. This mine is now on fire, and has been burning since the year

FIG. 8.



Section from Mauch Chunk to Locust Mountain.

1857. At the edges of the basins of all these regions the number of seams is less, the upper ones being washed off. The precise number and aggregate thickness of the beds of coal in some parts of these anthracite regions are matters of some doubt, especially to determine which are repetitions of the same bed. There are also numerous thin seams, which, while they might be valuable elsewhere, are here neglected on account of their small size. Throughout the anthracite regions they are almost always called veins, but that term properly applies to irregular fissures running across the rock-strata filled with mineral substances. Coal is always in seams running with the rocks, and the larger seams are called beds.

Description of the Coal-Basins.

The *First, Southern, or Schuylkill Coal-field,* extends in a continuous body in an east and west direction, inclining a little toward the southwest, from a point near the Lehigh River at Mauch Chunk, to a point near the Susquehanna River, six miles north of Harrisburg; its extreme length is 73 miles, with a mean breadth of two miles and a maximum breadth of five miles. North of, and near the centre of the main field, directly north of Pottsville, is the small detached field called Mine Hill, which is 14 miles long. This southern coal-field is principally in Schuylkill County, but the eastern point, the Lehigh Navigation Company's mines, is in Carbon County, and the ends of both the western forks or extremities of the field are in Dauphin County. It is everywhere penetrated by railroads,

FIG. 4.

MOUNT PISGAH INCLINED PLANE AT MAUCH CHUNK, PA.—Built in 1826, being, with its gravity railroad, and several other connecting planes, at that time, the longest railroad in the United States, and the first, except that at Quincy, Mass., which was completed two months earlier. This "Switch-Back" Railroad, as it is called, has been superseded by a tunnel at Nesquehoning, and is now only used for excursions.

consisting almost exclusively of the Philadelphia & Reading Railroad and its numerous branches, leading to all the collieries, but none of the great lines of through-travel, either east and west, or north and south, pass through it, except the Catawissa Railroad, which crosses it at Tamaqua.

The Southern, or Schuylkill coal-basin, extending from the Lehigh to near the Susquehanna, is very irregular in its configuration and structure. For convenience, it should be divided into districts commencing at the east or River Lehigh end, and going westward.

First, we have the *Lehigh and Little Schuylkill* district. Although the coal-field, as correctly represented on a map, approaches within about a mile or two of the river Lehigh, it is high above it, the east point of the field being at least 1,000 feet higher, and it lies in the embraces of two high contiguous mountains, which seem to have been united for its protection, without any gap or opening at the Lehigh Valley. Here are situated the famous switch-back railroad and inclined planes of the Lehigh Coal & Navigation Company, by which the coal is carried over this high mountain-barrier to market. These two mountain-ridges diverge from the knob, on the river Lehigh, called Mount Pisgah, and extend westward, gradually separating, but with no considerable deviation from straightness, as far as Tuscarora and Middleport, about 19 miles, and with no break of continuity, except the simple notches which give passage to the streams, especially the gap at Tamaqua, for the passage of the Little Schuylkill. This geologically beautiful division of the coal-field has a trough-like structure, gradually expanding and deepening toward the west, and is confined on each side by steep and regular mountain-slopes. The ridge on the south side is the Sharp Mountain, on which the average dip of the coal-seams is about 80°, while the dip on the Locust Ridge, on the north side of the valley, is between 50° and 60°. These two mountains thus form the eastern elevated prow of a vast canoe or trough, the coal-area, from a mere point at the east end, widening to about a mile and a half opposite Tuscarora. The coal-seams are here developed in their greatest magnitude, and are situated in the sides of both mountains, and run with the mountain-slopes down to the bottom of the valley to an, as yet, un-

known depth, and extending in a similar manner up the side of the opposite mountain, but with a number of subordinate folds or flexures, in some of which the coal-seams are vertical. Within this first district are a number of smaller localities which, as they are often spoken of, should also be mentioned, commencing at the east end and continuing westward. Nesquehoning is a mining village north of and outside of the east end of the field, where a small stream, called Rhume Run, passes out of the coal-valley into Nesquehoning Creek, a tributary of the Lehigh. A railroad tunnel now passes through this mountain. Summit Hill is on the top of Sharp Mountain, on the south side of the basin, where the first mine was opened in the great quarry before described, where the seam was doubled together in a large mass of coal. From this point in the valley, westward, the surface is drained by Panther Creek, which runs westward, past Coaldale and Greenwood, to the

Sharp Mt. Fig. 5. *Locust Mt*

Section at Tamaqua.

Little Schuylkill at Tamaqua. The latter stream there cuts through Sharp's Mountain, and flows over the red shale, and through the second mountain. The region above described produces the famous "Old Company's" iron-melting Lehigh coal, and is usually reckoned with the Lehigh small basins, as the coal is similar.

The second of Prof. Rogers's division is the *Schuylkill and Swatara District*. There is an abrupt widening of the coal-basin at Middleport, and this district extends from this point, a little north of westward, to the forks of the basin north of Pinegrove, at Lorberry Creek, the north fork of the Swatara. This portion of the field is 22 miles long, and in its central and widest part about four miles broad. Mine Hill is its northern and Sharp Mountain its southern boundary. In the Sharp Mountain, the rocks have been uplifted and tilted over beyond the perpendicular, so that they lean over, as it were, northward, against the coal-measures in an inverted position, crushing and destroy-

ing the coal-seams, so that, instead of dipping northward, or into the basin, they dip at a high angle toward the south, and in some places they are perpendicular. This most extraordinary condition of things extends from opposite Middleport, nine miles east of Pottsville, to near the extreme western end of the Dauphin prong of the basin, a distance of about 30 miles. The structure of the northern boundary, Mine Hill, on the other hand, is anticlinal, dipping southward into the Schuylkill basin, and northward into the Mine Hill basin. The Locust Mountain, which forms the northern boundary of the first district, ranges from Middleport, more northwestward, into Broad Mountain, while Mine Hill rises near Tuscarora and ranges westward, in an almost straight course, being a well-defined ridge, exposing the conglomerate under the coal on its summit. It separates the Schuylkill Valley, or Pottsville coal-field, from a smaller basin on the north, which is called the Mine Hill basin. It is nearly opposite the east end of Mine Hill, where the Sharp Mountain exhibits the remarkable change in the position of its crest before mentioned, suddenly shifting to the south more than half a mile, and, abruptly widening the coal-field, thence westward, the whole mountain, as one mass, being violently dislocated, laterally. The south rim of the basin appears to have been broken by a greater force having been exerted against it on the eastern than on this central portion.

This wider, middle part of the coal-field, contains a number of subordinate anticlinal flexures, or saddles, some of them in the form of inverted folds of the coal-measures, several miles in length, besides many local contortions and irregularities of the dip. This district includes the most important part of the Schuylkill basin, drained by the river of that name, having Pottsville for its central point; also, Port Carbon, St. Clair, Minersville, Swatara, and Tremont, with numerous collieries, and mining towns, and its surface is very much diversified by the undulating character of the strata. The more southern basin, in which Pottsville is situated, is the largest. Daddow gives its dimensions as one mile wide and 50 miles long.

Rogers, in his second annual report, describes the ponderous conglomerates of Sharp Mountain as overtilted, and leaning in an inverted attitude on the coal-seams, which must lie buried in

a more or less crushed condition for several thousand feet beneath its base. In consequence of the disruption of the coal-measures, and the overtilting of their strata, the coal-seams have sustained a greater or less degree of crushing action, the result of a sliding of the beds in the plane of their stratification. In such a movement, the greatest amount of crushing force would take place in the coal-beds, which are the weakest layers, and the strata have experienced an unequal lateral bulging, and the coal-seams show the effect of a rubbing pressure to an extraordinary degree. A piece of coal larger than a nut can scarcely be found, that does not give proof that its parts have been violently crushed. The coal crumbles into flakes, and the roof and floor sometimes approach nearly to touching, and at others recede beyond the proper space which should divide them.

The compressing force seems to have been exerted most strongly from the south or southeast, as the crests of the waves seem to be urged forward from that direction, and consequently, throughout the Schuylkill region, the inclination on the south side of the basins is considerably the more abrupt. The dips toward the north exceed those toward the south. The intelligent miners are aware of the relative unproductiveness of the north-dipping portions of the strata. There are places in the other anthracite regions, also, where portions of the coal are crushed and destroyed by these disturbances, and even reduced to powder. These circumstances are evidence that the coal could not have been originally deposited in its present basin-like form, and that it was in some measure hardened at the time the disturbances of the strata took place. It illustrates what is seen in Rhode Island, and among the squeezed-up fragments of anthracite in Virginia.

But too much space has been given to this, which is only one of the curiosities of the subject. The real wonder of this famous Pottsville region is the great Mammoth bed of coal, which is often as much as 30, 40, and in some places even 50 feet in thickness, and which lines the slopes of these bleak, barren hills. Millions of tons of the finest coal have been mined from it above water-level, and, as you pass through these valleys, near the summits of the hills can be seen long lines of fallen-in outcrop, showing where the great coal-bed has been

robbed of its treasures from the foot to the summit of the ridges. The mining in the older mining-districts is now done by slopes and shafts below water-level.

Nothing in the geology of the anthracite regions is more remarkable than the tenacity of the strata, which, as a general rule, follow each other faithfully through all the numerous foldings and undulations, without great faults or sudden breaks by which strata usually far separated are brought together. The English coal-fields show numerous faults, one of the most celebrated of which is the 90-fathom dike in the Newcastle coal-field. Some of their faults are 30 miles long, and in other localities smaller faults occur every few yards. Along the east margin of the great Alleghany coal-field in Virginia, Tennessee, and Alabama, from some cause the formations, which in Pennsylvania present these remarkable swells and convolutions of all the strata in a body, are there characterized by true faults or cracks, some of them 100 miles long, bringing up some of the oldest formations against the edges of the most recent.

The third division of the southern basin is the separate and smaller synclinal trough of *Mine Hill.* It is between 13 and 14 miles long, and from a fourth or half a mile wide at its east end to a mile where it is broadest, and has a fine thickness of coal. Its north boundary is Broad Mountain, into which, indeed, its two extremities may be said to penetrate, and it forks at its west end into two branches by the intrusion of the Peaked Mountain.

The fourth and fifth divisions of the main coal-field consist of the two prongs which form its western ends. These are caused by the intrusion from the west of a broad anticlinal belt of conglomerate, and still lower rocks, forming the Little Lick or Stony Mountain, and the valleys west of it. This causes the basin to separate into two long and narrow synclinal troughs, the more southern of which is called the Dauphin basin, and the more northern the Wiconisco or Lykens-Valley basin.

4. The *Wiconisco basin,* or northern and shorter of these western extremities of this anthracite coal-field, is nearly 17 miles long, and in width, measuring from one outcrop of the conglomerate to the opposite one, is from a mile and a half to three-quarters of a mile, tapering gradually to a point, with a

structure very similar to that of the first or Tamaqua division. Its bounding ridges are the Big Lick Mountain on the south, and the Bear or Thick (sometimes called the Short Mountain) on the north, both of them with their strata dipping toward the coal-measures, with a synclinal axis along the centre of the trough. Rausch's or Klinger's Gap is the outlet on the north side, and near the centre of the field, and Bear Gap on the south side, through which the railroad is built.

5. *The Dauphin basin*, or southern fork of the Schuylkill field, is about 27 miles long, and has a breadth of nearly a mile at its eastern end, but contracts gradually to half a mile between Rausch's Gap and Yellow Springs Gap, and still farther westward it tapers away to a very narrow belt; the bed of the valley rising all the way, until the coal-measures terminate in a long and acute point at an elevation of many hundred feet above the valleys outside of the bounding mountains. The end of the coal-measures, as they are pressed and folded together between their two mountain-barriers in the high, narrow mountain-trough, is within four miles of the Susquehanna River. The outside mountain, separated by the red shale from the coal-basin, is the Second Mountain end seen on the east side of the river Susquehanna above Harrisburg, at the little town of Dauphin, where the Northern Central Railroad bridge crosses the river. Peters's Mountain, farther north, called the Fourth, is the northern outside mountain, and the cove on the Perry-County side is formed by their junction at their extremities. The Third Mountain contains the coal-basin between them. This Dauphin basin is a simple, compressed synclinal trough, the strata on the south side dipping perpendicularly, while those on the north side decline south at an angle of 45°.

We thus find that both the west and the east ends of this great Schuylkill coal-basin terminate in elevated mountain-valleys, each with its two mountain-rims coalescing, the one high above the Lehigh at Mauch Chunk, the other high above the Susquehanna at Dauphin. Travellers on either of the two fine railroads along the Lehigh River, the Lehigh & Susquehanna, or the Lehigh Valley Railroad, unless informed, would never suspect that the high mountain which presents its end above Mauch Chunk, crowned with the tall chimneys of the inclined

plane, held within it a mountain-valley filled from side to side and from end to end, and extending eastward more than 70 miles, with the most wonderful seams of the finest coal in the world, in an abundance and richness altogether unequalled. In the same manner the western termini of this wonderful coal-deposit are enclosed by the same mountains turned up edgeways, as their southern and northern boundaries, and closing around their ends, with their numerous seams of coal also turned up on their edges, running deep down into tne bottom of these basins to unknown depths, where generations to come will follow them in search of fuel. It should be noticed, too, that as the Lehigh River cuts through the outside mountain-frame, and runs, at Mauch Chunk, at the foot of the coal-bearing mountain, leaving a loop-shaped fraction of the mountain east of the Lehigh, so also the Susquehanna River cuts off loops from both of the forks of the west end of the same mountains, leaving similar fractions of the Vespertine Mountains on the west side of that river, in Perry County; that of the Lykens-Valley or Wiconisco fork lying between the Susquehanna and the Juniata opposite Newport, and the other forming the cove opposite Dauphin.

We must not leave the Schuylkill or first coal-field without a word as to its appearance. A further notice of this will be given at the close of this chapter, but no reader who has not seen it will believe its wonderful sterility. Its soil will produce absolutely nothing in the way of rewards to the husbandman. A more unpromising-looking country cannot be found in the State, except its sisters Mahanoy, Shamokin, and the Lehigh basins. The entire area of the various parts of the Schuylkill coal-field is estimated by P. W. Sheafer, a distinguished geologist and mining engineer of Pottsville, as follows:

	Length.	Square Miles.
Mauch Chunk to Tamaqua	14 miles.	16
Tamaqua to Pottsville	16 "	36
Pottsville to the forks of the basin	14 "	55
North Fork, or Lykens-Valley Prong	17 "	16
South Fork, or Dauphin Prong	27 "	15
Area of Schuylkill Basin	....	138
Mine Hill Basin	13 miles.	8
Total area of first coal-field	....	146

It may aid the memory to retain the figure on the map of this southern coal-field, by noticing its resemblance to a rude drawing of an open-mouthed alligator without legs, with his tail toward Mauch Chunk, the Mine-Hill field is his dorsal fin, Tremont is the eye, Pottsville the heart, and the Philadelphia & Reading Railroad, with its numerous branches, represents the veins and arteries.

Second Coal-Field.

The Shamokin and Mahanoy portions of the second and middle coal-field, Prof. Rogers says, are essentially one great coal-field, there being no belt of any older rocks than the coal conglomerate, and that of no very great width, partially subdividing the two regions. The names by which these two large and important fields are commonly known are derived from the two creeks by which they are almost exclusively watered. The eastern district, south of the dividing ridge, called Locust Mountain, is drained by Mahanoy Creek, which empties into the Susquehanna River at Port Trevorton, and is called THE MAHANOY REGION. It is 25 miles in length, with a mean breadth of less than two miles, and contains 41 square miles. Its southern boundary is the Mahanoy and Broad Mountain, and on the north it is bounded by the Big or Head Mountain. Its western extremity is bounded on the north by the Locust Mountain, which penetrates between the Mahanoy and Shamokin basins without entirely separating them on the north side. The nearest station on the Lehigh Valley Railroad to this division of the two regions is Centreville. This basin is nearly all in Schuylkill County, the west end only being in Northumberland and Columbia Counties.

The Mahanoy coal-field consists of a rather high, rolling table-land, between the summits of its bounding mountains, the outer barriers of the coal-measures. It contains undulations, but, unlike those of the Schuylkill basin, they are characterized by remarkable symmetry. It is traversed longitudinally, or in a nearly east and west direction, by three and probably in some quarters four nearly parallel gently-swelling ridges, dividing the region into about four very moderately-depressed valleys. These valleys are so many almost regularly-formed little coal-basins,

in which the coal-measures, as a general rule, have a very gentle dip toward the interior of each basin, or away from the bounding ridges. The ridges contain broad, rounded, obtuse anticlinal axes, having the dips on both sides symmetrical, exposing on their summit the conglomerate beneath the coal. On these ridges no coal is found; but some of the valleys, on the other hand, are richly supplied with coal; two or three of the seams, which are those at the base of the formation, being of great thickness, though the total depth of the coal-measures is considerably less than those of the deepest part of the Schuylkill basin.

The mining done in the Mahanoy coal-field, since Rogers's reports were made, has proved the very remarkable size of the coal-seams in this basin. The two great coal-carrying railroads, the Philadelphia & Reading and the Lehigh Valley, both penetrate the Mahanoy coal-field, the former from the south, and extending mainly along the lower or central and southern side of the basin; and the latter, which was afterward constructed, entering from the east, and extending along the north side of the basin. Both have numerous branches, leading to the various collieries. The important mining towns of the Mahanoy region are Mahanoy City, Shenandoah City, Girardsville, Ashland, Preston, Locustdale, and Centralia, some of them large and important places. This sketch of Mahanoy is necessarily brief; but this is one of the best and richest of the great anthracite coal-basins. Being less accessible than the first or Schuylkill region, mining was commenced here later, and a larger portion of its valuable treasures of fuel remains to be developed.

The SHAMOKIN BASIN is drained by the Shamokin Creek, which empties into the Susquehanna River at Sunbury, and is the western portion of the second or middle coal-field. This field is 20 miles in length, with a mean breadth of two and a half miles, and its area is 50 square miles. This, with the 41 square miles of the Mahanoy, makes the total area of the middle coal-field 91 square miles, besides the small Lehigh basins. The Shamokin basin is nearly all in Northumberland County, with a few collieries at the east end in Columbia County. It is

bounded on the south by Locust Mountain, separating it from the Mahanoy, and extending to the extremity of the basin; but the west end of it is frequently called the Mahanoy Mountain. On the north the boundary is the Thick or Shamokin Mountain. The western end of the great Shamokin coal-field is not unlike the east and west termini of the Schuylkill field. The north and south dipping ranges of uptilted conglomerate, which form the margins of the basin, unite together in a high knob, between eight and nine miles west of Shamokin Gap, and about 10 miles west of the Susquehanna at Port Trevorton, in a direct line. From the western terminus of the Shamokin coal-field eastward there is a regular basin of coal-measures of uncommon width and depth. The Shamokin field consists of three sub-basins, according to Rogers, while Daddow's section indicates more, and it affords a fine display of numerous coal-seams of a good workable size.

There is little doubt that there are thirteen separate seams of coal in the Shamokin coal-field, all of which have been cut and worked at some point to a greater or less extent; but there is no place where so many are found of a workable thickness. In respect to all these coal-fields, it should be understood that the exploring for and opening of coal-seams are attended with considerable expense; and, if a few seams of sufficient size and producing a good quality of coal are found, there are but few coal operators or companies who care to expend money in explorations to prove the entire contents of the coal-measures. The upper seams, being most accessible, are generally first worked. Nos. 11 and 12, numbering from the bottom of the basin, are red-ash coals; and No. 13 is generally too near the surface to be cared for. Nos. 10, 9, and 8, the next in descending order, are all good workable seams; Nos. 9 and 8 being called the Twins, and are supposed to be the Mammoth, which is separated into two seams. These three are extensively wrought, and vary in thickness from 7 to 10 feet. The dip of the coal on the north side of the basin, or the south dip, as it is called, will average 25°; the coal-seams rising to the summit of the mountain, 730 feet above water-level in the valley, in perpendicular altitude, at the town of Shamokin, affording a very large quantity of coal above water-level. The depth of the basin has not been ascertained by mining.

The branch of the Lehigh Valley Railroad which passes through the Mahanoy coal-field extends westward to Mount Carmel. The Northern Central Railroad extends from Mount Carmel through the Shamokin basin, passing out of it through a fine natural opening on its north side, called Shamokin Gap, at the town of Shamokin, and thence to the main line of that road at Sunbury.

The Philadelphia & Reading Railroad extends through the Shamokin basin, and out by Shamokin Gap, and thence pursues its course westward along the red-shale valley to Trevorton, where it receives a tributary from the collieries in the basin, and thence it runs to Port Trevorton on the Susquehanna, 41 miles north of Harrisburg. The first mountain below Sunbury, on the Northern Central Railroad, is the outside rim of the Shamokin basin, which here terminates, whereas the two west prongs of the first or Schuylkill basin extend across the Susquehanna, as before described.

It appears, by Mr. Bannan's statistics for 1871, that in the first and second coal-fields, exclusive of the Lehigh basins, there were 209 collieries in operation, which in that year produced 5,124,780 tons of coal, mined, prepared, and sent to market, and about one-sixth of this quantity is estimated to have been wasted in the coal-breakers.

The Lehigh Coal-Basins.

The Lehigh coal-fields consist of seven narrow basins lying contiguous to each other, separated by six anticlinal axes or undulations of the dip, and containing the lower coal-beds of the series, one of which is of great size and importance. The Lehigh River, between White Haven and Penn Haven, is the eastern boundary of this important region. These basins may be compared to a like number of long and narrow troughs lying in contact, and parallel to each other, ranging generally S. 65° E. to S. 70° E. These are separated from each other in every case by parallel anticlinal ridges of conglomerate rock, or, when that has been carried away, from a deeper denudation than usual, they are then divided by narrow valleys of the red shale. The latter is the common structure of the eastern and western extremities of the coal-fields, where we find the coal-basins termi-

nating abruptly in a prow-shaped form in those conspicuous mountain-spurs or high promontories which stretch eastward and westward from the elevated level of the coal-field into the lower red-shale valleys of the Lehigh and Catawissa.

The Lehigh coal-basins, although small in area, are very productive and important, and afford an excellent quality of coal. This group of basins, taken together, is bounded on the south by the red-shale valley of the Quakake, on the east by the valley of the Lehigh River, and on the north by that of the Nescopec. Its railroad outlet is by several branches of the Lehigh Valley Railroad, leading from the main line at Penn Haven, on the Lehigh. The country consists of a high, rolling table-land, of a maximum elevation above the sea of a little less than 2,000 feet.

The more southern of these coal-basins is that of *Beaver Meadow*, bounded by Spring Mountain on the south, and Buck Mountain on the north. The greatest length of the coal-measures is about seven miles, with an average breadth of one mile, though at Jeansville it is one and a fourth mile wide. The east end of the general basin separates into two prongs. It contains the old Beaver Meadow mines, no longer worked, with those of Tresckow, Jeansville, Yorktown, Audenreid, Honeybrook, Coleraine, and Spring Mountain. Beaver Meadow basin is situated at the corner between the three counties of Carbon, Schuylkill, and Luzerne, and a small part of it is in each. The other upper Lehigh basins to be described are in Luzerne County. Rogers next describes a North Beaver Meadow basin on Dreck Creek, lying on the north slope of Buck Mountain, which is comparatively unimportant. The third of the Lehigh coal-basins is that of *Hazleton*, in the southern corner of Luzerne County, the most capacious and important in the district. Its western end forks at Cranberry into two long branch basins, divided by a ridge of conglomerate. The main or large coal-seam of the Hazleton basin has a length of from five to five and a half miles, and a maximum breadth west of Hazleton of nearly three-fourths of a mile. The lower seams are a mile wide, and much longer than the above. In this basin are situated some important mines at Stockton, and those of A. Pardee & Co., at Hazleton. Hazleton village is one of the best-looking of these

mining-towns. It is situated directly on the coal-basin, the shales of which seem to afford a better soil than is usual in the anthracite regions.

Rogers estimated a total area of 1,700 acres of the great Hazleton bed, which yields of merchantable coal a thickness varying from 15 to 17 feet, equivalent to a net product, with good mining, of 20,000 tons to the acre, a production which implies an aggregate of marketable coal in the basin of 34,000,000 tons. The great bed consists of three main seams or benches of coal, yielding five feet of coal in the lowest, seven feet in the middle and the upper one, six or eight feet separated by slates of irregular thickness.

The configuration of this Hazleton basin, or the more central part of it, embracing the large coal bed, will be understood, says Prof. Rogers, when we state that the average degree of dip northward, along the southern outcrop, is about 25°, until it approaches its east end, where it is as steep as 45°. The north outcrop of the same coal exhibits at the various collieries south dips varying from 20° to 30°, except at Carter's slope, where the outcrop shows a steepness of nearly 50°. On the north side of the basin the dip appears to flatten in descending toward the centre or bottom of the basin, whereas the curve steepens in the Stockton colliery on the south side. It is supposed that the centre of the basin is more or less undulated, from the absence of a considerable series of coal-seams which should overlie the great bed, and which are not found here. The basin, however, is remarkably free from faults or disturbances, to cause a waste of coal in mining, and the reader will observe, from the above description, that, small as is its area, it must have great depth. There is now a slope on the Big seam 800 feet in perpendicular depth below the surface. The full depth of the basin is estimated to be 1,500 feet. The Big seam is 30 feet thick, of which 18 feet is prime coal. Hazleton is a very small basin, but there is probably no more valuable coal-field of the same size in any part of the world.

The *Buck Mountain* is the eastern extremity of the Hazleton basin, although the coal-field itself is far east of the other productive parts of the basin. This is an old and well-known mine. The coal-seam displays 16 feet of excellent coal, ac-

cording to Daddow, and is not the Mammoth, but B, a lower seam, and produces a quality of coal well adapted for steam-purposes.

Of the other small coal-basins of the Upper Lehigh region, situated north of Hazleton and on the waters of Black Creek, but little was known at the time of our State geological survey, but they have since been quite extensively developed. First north of Hazleton is the *Big Black Creek* basin, which Daddow reports as 12 miles long, with an average width of half a mile, containing the fine productive collieries at Eckley, Jeddo, Drifton, Ebervale, and Harleigh, the coal of which goes to market by the Lehigh Valley Railroad, through a tunnel in Council Ridge, which separates it on the south from the Hazleton basin. On the east end of this field, the Buck Mountain Coal Company have collieries, with planes over Council Ridge.

The *Little Black Creek* basin, seven miles long by three-eighths of a mile wide, contains the Milnesville Coal Works.

Black Creek empties into the Nescopec Creek, which runs into the North Branch of the Susquehanna, opposite Berwick, and the *Lower Black Creek* basin lies west of those last named. It is 10 miles long by half a mile wide, and is as yet undeveloped by collieries sending coal to market. The Danville, Hazleton & Wilkesbarre Railroad was completed through this basin in 1872.

Northwest of the Lower Black Creek basin is another small, insulated, undeveloped coal-basin, on the summit of McCauley's Mountain, situated about nine miles east of Catawissa. Rogers reports it as about two miles long and a fourth or a third of a mile wide, with at least two large coal-seams. North of Eckley and Jeddo is situated the Green Mountain basin, to which runs the Nescopec Branch of the Lehigh & Susquehanna Railroad. Rogers reports it as being composed of two basins, two and a half miles and three-quarters of a mile long respectively, and a half and a quarter of a mile wide. Daddow gives the dimensions as seven miles long and three-eighths wide. The line of elevation, bounding the south side of this basin, crosses the Lehigh River in the neighborhood of White Haven, and runs about west by south to the great bend of the Little Mountain, near Catawissa. The small coal-field of Mc-

Cauley's Mountain is in the same basin farther west. The flexures of the Lehigh basins extend to the lower rocks, and can be seen along the Lehigh River, in travelling by either of the fine railroads between Mauch Chunk and White Haven. Only branches of these railroads run to the coal-basins.

The following is Daddow's list of the names by which the Lehigh basins are known, their length, width, and area in square miles:

	Miles long.	Miles wide.	Square Miles.
1. Beaver Meadow...............	11	¾	8¼
2. Hazleton.....................	14	¾	10
3. Big Black Creek..............	12	½	6
4. Little Black Creek............	7	⅜	2½
5. Lower Black Creek...........	10	½	5
6. Green Mountain...............	7	⅜	2¼
7. McCauley's Mountain, and others,			3
Total area Lehigh basins....................			37

The area of some of the Lehigh basins is said to have been increased by recent explorations.

The total production of Lehigh coal, in the year 1873, was 3,243,168 tons, and, since the opening of the trade, 49,160,635 tons. In a recent publication, Mr. Lesley says that, in the Lehigh basins north of Hazleton, the Buck Mountain, or lowest notable bed (B) of the series, is the great bed of the collieries, in thickness running from 20 to 30 feet, and in quality excelling all the other anthracites. Nearly north from this point, at Plymouth, in Wyoming Valley, this bed also attains the extraordinary size of 24 feet.

This is merely a rapid sketch of some of the most important coal-regions on this continent. It is impossible to do justice to them within the limits assigned to this volume. The reader must look at the statistics showing their large production of coal, and, if he desires further details in regard to any of them, he must refer to Rogers's final report, and the other work already mentioned, which is more especially devoted to the anthracite coal-regions.

The peculiar importance of this Lehigh region, and the eastern extremity of the southern or Schuylkill field at Mauch Chunk, consists in the valuable qualities of the coal which they produce. Almost everywhere in America, the first branch of

manufacturing business that is established, even in the smallest villages, is a foundery for the manufacture of articles made of cast-iron. For this purpose, pig or ordinary cast iron must be melted, and for this work Lehigh coal must be used, if it can possibly be obtained. In the most remote parts of our country, in the States on the Mississippi River, on the Pacific coast, in the interior of our far Western Territories, all through the South, as well as in the more populous regions and large manufacturing cities on the Atlantic slope, Lehigh coal is one of the great necessities of manufacturing. No coal-dealer, anywhere in the country, has a stock of coal to supply all his customers, if he has no Lehigh. Its special qualities consist in its large amount of carbon, its purity, and its hardness. By passing a strong current of air through it, when ignited, an intense heat can be procured, sufficient to melt cast-iron. The coal is sufficiently hard not to fall in pieces, and thus stop the draught, but retains its form until it is consumed, owing to the absence of the water found in other anthracite coal. Lehigh coal is also used very extensively for domestic purposes and for steam, but it is more difficult to kindle, and less easily managed, than the softer anthracites. Where the genuine Lehigh coal cannot be procured for foundery purposes, the other and softer varieties of anthracite are substituted, and, where they are out of reach, coke from bituminous coal is used.

The third or northern coal-basin is separated from the middle field by the great anticlinal axis of the Wapwallopen Hills, by which the rocks of four of the great formations below the coal are brought to the surface. On either of the railroads from White Haven on the Lehigh River to the summit of Wyoming Mountain, a very extensive view of this region can be seen, particularly that extending for many miles to the west, all of which is destitute of coal.

General Geological Structure of the Third Coal-Field.[1]

The general configuration of the Wyoming basin is a wide and shallow trough, deeper in the middle than at the sides, yet deepening so gradually toward the centre as to be, if we disre-

[1] Condensed from a report, by H. D. Rogers, on the coal-lands of the Delaware, Lackawanna & Western Railroad Company.

'A First Glimpse of Wyoming Valley, as seen from the Lehigh Valley Railroad.

ard the subordinate undulations of the strata, approximately flat. This prevailing levelness of its bed or floor, notwithstanding the considerable angles of dip, frequently more than 30°, is at once apparent when we compare the great width of the valley, four or five miles in its middle district, with the very moderate depth of 1,200 or 1,500 feet, or perhaps 1,800 feet.

Within the general basin are a number of nearly parallel lesser troughs or basins, with intervening saddles or anticlinal waves in the coal-strata. The same coal-seams and other strata are repeated from one wave to another, so as to maintain, despite the local steepness of dip, this average uniformity in the depth of the coal-field at any given cross-section.

The whole coal-valley may be likened to a flat-bottomed boat, tapering gradually from the middle toward each extremity, and as gradually shoaling up in those directions; but the boat is not a straight one, as it curves constantly, crescent-like, toward one side; and the resemblance is further deficient in the bottom not being smooth, but ridged with the waves above spoken of. This shoaling or thinning, by superficial removal of the coal-measures toward either end of the trough, though locally modified by the undulations, is not a uniformly progressive feature, but advances more suddenly and then more slowly along certain portions of the valley. Thus it seems to proceed rather rapidly from Wilkesbarre, northeastward, past Pittston; and to be almost arrested thence along the Lackawanna Valley from near the mouth of Spring Brook, until we pass beyond Scranton; while a more rapid lifting out of the strata seems again to commence near Leggett's Gap, and to continue steadily to the termination of the basin at Carbondale.

General Features of the Undulations of the Third Basin.

The anticlinal and synclinal waves or saddles and troughs of the strata have a remarkable parallelism throughout the entire range of the basin, irrespective of the bending course of the main valley and its including mountains. Those of the Lackawanna Valley range about north, 67° east, and are parallel to each other; those in the vicinity of Wilkesbarre differ from the former about 6°, ranging about north, 72° or 73° east. It is only in the lower or west end of the valley that these rolls of

the strata are parallel, or even nearly so, with the main course of the valley, approaching to a coincidence in direction with the mountain forming the southern side of the basin. As we proceed thence northward, the obliquity of the undulations to the line of the basin and its barriers grows conspicuously greater.

There is a curious declining gradation, observable in the sharpness of the successive undulations, as we proceed from the southwest to the northeast along the basin. Not only does each anticlinal of the southeastern side of the valley grow gentler or flatter in its dips as you follow it eastward, but the successive ones are fainter and fainter as you cross them obliquely in going toward the northeast. Those, of all the lower or western end of the valley, from Beech Grove to Nanticoke, show inclinations as high as 45°; those between Nanticoke and Wilkesbarre show dips exceeding 30°; while, following the Lackawanna division of the basin, we have no longer any thing approaching this last steepness of flexure, except just near the ends of the saddles; but rather a low, broad waving of the rocks, growing feebler and feebler as we advance, until, passing Scranton into the district between it and Archibald, regular undulations become almost imperceptible, and are lost in the very gradual dips into the middle of the general trough, from the two borders of the valley. Accompanying this progressive smoothing out of the waves or corrugations of the strata from the southwestward toward the northeastern end of the whole basin, there is a like gradual transition or declension in the topographical features—from sharp and narrow-crested ridges and deep hollows to rounder and gentler spurs and valleys; and, along the Lackawanna, to wide-topped summits, bluffs, and open, denuded plains.

The main feature in the individual waves is the steepening of the dips on both sides of the anticlinals as we advance from the mountain-sides, where they originate out into the central tracts of the valley to near their terminations, which are therefore comparatively abrupt. Thus, between Wilkesbarre and the Lackawanna, the anticlinals, as traced from the eastward, will be seen to grow steadily sharper and sharper in their dips until they approach the Susquehanna, in the neighborhood of which

they nearly all subside by rounding rapidly off. The river itself seems to have been unable to pass the successive barriers presented by the ridges in the strata, and to have been thus forced toward the outlet of the drainage of the valley, the wide notch in the northern mountain-barrier at Nanticoke.

Besides the long, parallel, tapering anticlinal waves coming very acutely off from the mountain-borders of the basin, there are numerous shorter and narrower ones, having the form of oval keels or saddles, which do not run into the mountains, but lie more or less insulated between these. From Scranton to Carbondale these become the prevailing type. In the uppermost parts of the Lackawanna basin the flexures of the strata are less continuous waves or ridges, than a succession of these elongated elliptical swells, some of them bulging into considerable steepness, but the chief part of them low and gentle waves.

There are also small, irregular, subordinate rolls, or short and narrow but not always flattish wavings of the strata on the flanks of the principal anticlinals. In the Wyoming and Lackawanna coal-fields, and other regions of oblique anticlinals, they are themselves oblique to the axes of the great waves which sustain them. These secondary rolls are numerous near Wilkesbarre. In some of the other anthracite regions, however, these secondary flexures, whether on the backs or sides of the main saddles, or in the troughs between them, are parallel with the principal undulations which support them.

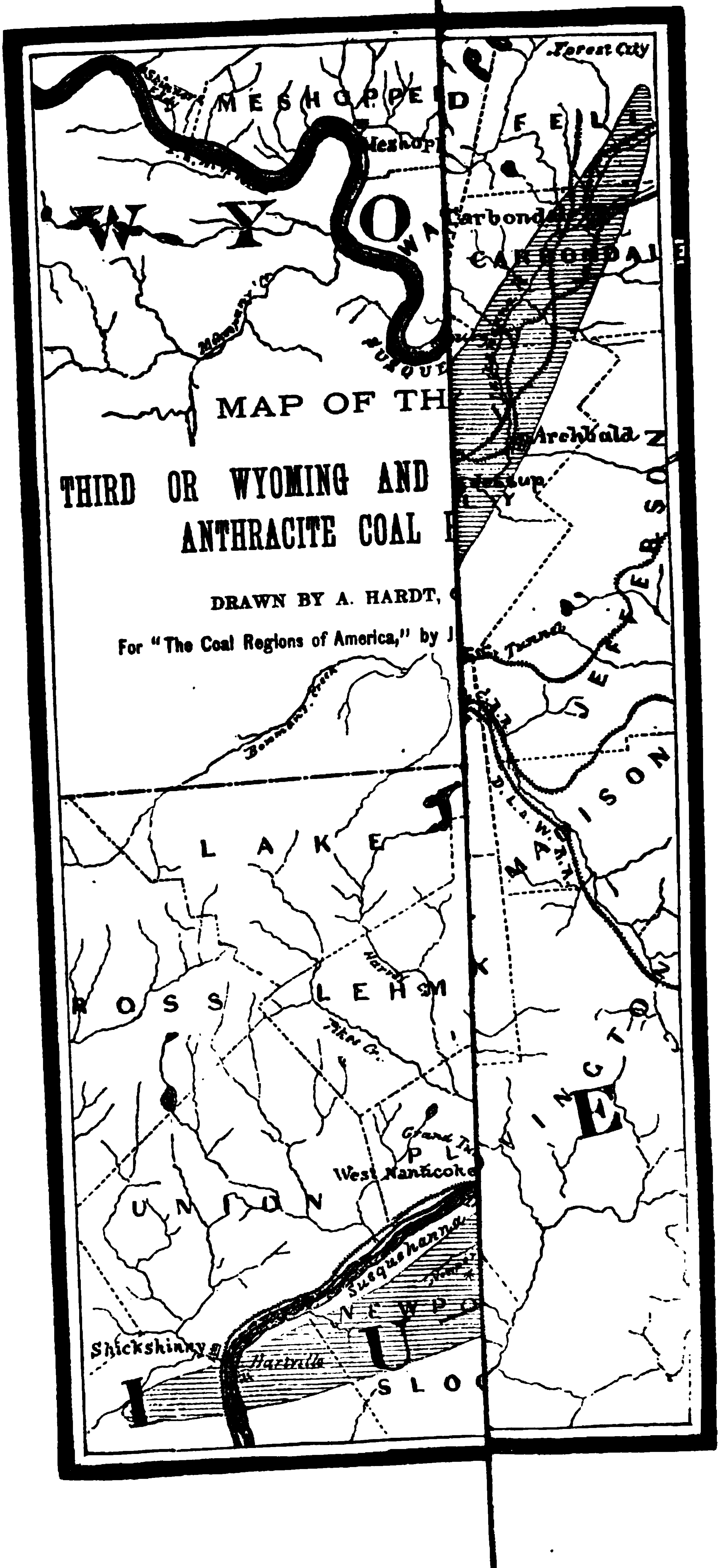
The undulations in the Wyoming and Lackawanna coal-field exhibit the same feature, of a greater steepness of dip on the northwest sides, which characterizes the chief part of the secondary flexures of the Pottsville basin. But, inasmuch as all the inclinations of the rocks in this northern district are far gentler than those of that southern basin, in the same proportion is the inequality less in the slopes of the opposite sides of the anticlinals. It is much more conspicuous in the southern or western end of the Wyoming Valley than in the Lackawanna Valley, where all the flexures are flatter.

Such is the structure of this curiously-fashioned, beautiful coal-field of the Wyoming and Lackawanna Valley. Some account of the coal-seams, as they are displayed in its various parts, is now necessary.

A stratigraphical examination of the anthracite measures of Pennsylvania calls for their division into two groups: a lower series, distinguished by the white or very pale color of the ashes of nearly all the coal-seams; and an upper series, including coals as remarkable for yielding only pinkish or red ashes. Between these groups there usually exists, especially in the southern or Pottsville basin, a small transition group of two or three beds of gray ash or pinkish-gray ash coals. The general resemblance between the anthracite and bituminous coal-measures in the upper, lower, and intermediate comparatively barren measures is evident, as well as in the position of the larger coal-seams B and E. The lower strata, both in the anthracite and bituminous coal-fields, abound in fossils of the larger species of plants, especially in *Lepidodendra,* or those trees having a scaly appearance of the stems, produced by the separation of the leaf-stalks; while the upper seams are characterized by the smaller herbaceous species, most generally the herbaceous ferns. These scale-plants have their greatest development at the formation of seam B, after which they gradually diminish, and are scarcely ever found above coal E, or the top of the lower coal-measures.

Prof. Rogers, in his final report, expressed the opinion that no correlation between the anthracite and bituminous coal-seams can be established; but later geological writers and mining engineers have no doubt about their identity.

As to the number and size of the coal-seams in various localities, a general account only will be here given, sufficient to satisfy the reader of their great abundance and the productiveness of all these regions. The lower coal-group contains, where it is fullest and best exposed, some ten independent coals; but there are not usually more than five of these of such dimensions and purity as to fit them for profitable mining. They are all liable to great fluctuations, both in size and purity. As to the size of the coal-seams, it should be understood that, while the great seams, from 18 to 24 feet thick, may excite the admiration of the reader, yet any anthracite coal-operator would prefer three or four separate seams, of six to nine feet each, to one of the larger dimensions, as seams of this moderate size can be wrought to better advantage, and a larger proportion of the coal can be mined.


MAP OF TH
THIRD OR WYOMING AND
ANTHRACITE COAL
DRAWN BY A. HARDT,
For "The Coal Regions of America," by J
Forest City
Carbondale
CARBONDALE
Archbald
West Nanticoke
Shickshinny
Hartville
Susquehanna
LAKE
ROSS
UNION
SLO
JEFFERSON
MADISON

Coal-Seams of the Scranton Coal-Field.

Taking the vicinity of Scranton as an illustrative example of the number and size of the coal-seams of the third coal-field, and commencing at the lower layer of coal in the series, we first meet with coal A, in two bands, as it always is in both the anthracite and bituminous fields. Here the lower is two feet and the other one foot thick, divided by a bed of shale four feet thick, and the seam is seldom fit for mining. Coal B is 35 feet higher, and is four feet of quite pure coal, but is not mined. Next in the series, and 31 feet higher, is coal C, called at Scranton the lower six-feet bed. This coal never rises to the surface, even on the highest anticlinal ridges, and six feet above it there is sometimes a two-feet seam. Coal D is 81 feet higher, locally called the eight-feet bed, and is fully of that thickness. It is overlaid by a rider seam, often four feet thick, separated by a shale varying from one to four feet. This seam D. is very valuable and underlies the whole field of the Scranton property. Above the last-named bed, at an interval of about 11 feet, there lies a smaller seam of two feet in thickness; this is improperly called E. Separated from the last by from 7 to 12 feet of shale and sandstone, we next meet the Big seam of Scranton, or the 14-feet coal, called locally F, but which is properly E. At the base of the hill, near the Lackawanna, its thickness is almost 15 feet. North of Scranton it is 14 feet, and yields good coal, some benches of which are of superior quality. At Leggett's Gap it is mined 12 feet in thickness, and it spreads widely underneath a large portion of the Scranton section of the basin, being lifted and depressed in the undulations which traverse the coal-field. Between 55 and 60 feet above the preceding lies the coal G, often called at Scranton the upper six-feet bed. It is very accessible, but other and larger beds are wrought in preference. Coal H is the 10-feet seam so called, and its prevalent thickness, wherever it has been mined or even proved in the Scranton coal-field, justifies the title. It is situated about 75 feet higher than the bed G, above described. This seam contains more than the ordinary proportion of good fuel, and the miners extract usually nine feet of it for the market. Coals I and K are sometimes called at Scranton the upper seven-feet and five-feet seams.

and present the unusual facilities for mining above water-level, which belong to the valuable 10-feet bed below them, from which they are separated by about 85 or 90 feet of strata. These two seams are 20 feet apart. Above the coal K there is generally, at a somewhat variable distance, averaging 12 feet, a thinner bed called L, the size of which fluctuates from two to three and a half feet. Coal M is the highest coal-bed in the Scranton series, which measures some eight feet in thickness; and its extent is not considerable, as only the higher parts and most synclinal or trough-like-dipping summits of the table-land can contain it.

In reviewing the foregoing description, we cannot but see, in a clear light, the remarkable productiveness of this portion of the lower coal-measures. The whole of this great store of admirable fuel is found, too, within about 400 feet of the surface. In fact, throughout the whole of all the anthracite coal-regions, the accessibility of the coal, even taking the greatest depth of the deepest basins at their supposed maxima, is one of the most important advantages. Taking the four middle beds at Scranton, D, F, G, and H, which lie within a thickness of strata of 200 feet, and spread beneath every acre of the coal-field, we find their least total thickness is 36 feet, their yield in thickness of good coal is upward of 25 feet, and their productiveness per acre 42,000 tons. Taking only the larger workable beds, and allowing for the wastefulness always practised amid such abundance, Prof. Rogers, in his report on the Scranton district, sums up his account with the following statement:

Coals.	Least Thickness.	Good Coal.	Yield of Good Coal per Acre.
K	5 feet.	3 feet.	4,000 tons.
I	7 "	4½ "	7,000 "
H	10 "	7½ "	12,000 "
G	6 "	3 "	5,000 "
F	12 "	9 "	15,000 "
D	8 "	6 "	10,000 "
C	6 "	4½ "	7,000 "
	54	37½	60,000

The foregoing details have been given in regard to the Scranton district, as it is one of the best-known and most pro-

ductive coal-regions. There are other localities, such as Mahanoy, Shamokin, and Wilkesbarre, where there might be a more remarkable display made of coal-seams, in larger number or of more extraordinary size.

The A seam is in the conglomerate, and is not well defined. The largest development of B, or the Buck-Mountain seam, in the Wyoming Valley, is in Plymouth, on the north side of the Susquehanna, from Nanticoke for four miles northward, at the Harvey, Thomas, and Smith mines. Here it works of a thickness of 20 to 24 feet of good coal. This is along the west rim of the basin. At a distance of eight miles above Nanticoke, on the north side of the river, its thickness is reduced to six feet, and thence to the head of the valley it is hardly of workable size. Crossing the river at Nanticoke to the south side, this seam B at Lee's mines is twelve feet, and it holds that size up to Warrior Run, thence it is 6 to 12 feet to Laurel Run, above Wilkesbarre. Between Pittston and Scranton, at Spring Brook, it is reduced to two feet, and at Scranton and Dunmore it is from two to three feet, sometimes four.

At Wilkesbarre an anticlinal brings the Mammoth seam up to the surface, where it was for a long time mined in open workings at the Baltimore Company's old mines, where great arches, 24 feet in height, were cut out of the cliff in the open daylight, at the very summit of the anticlinal wave. Rogers's report contains beautiful engravings of this mine. Nearer the river, the Lehigh Valley Railroad Company have lately sunk a shaft to the same Mammoth seam to a depth of 525 feet, which is just the level of the sea. This is an unusually deep shaft for this region. Another was at one time sunk farther south in Wyoming Valley 850 feet, or 325 feet below the level of tidewater, without reaching to the large coal-bed. No coal has been mined there, as a supply can be had at more convenient depth in other localities. At Wilkesbarre the Mammoth seam is known as the Baltimore vein, from the name of a coal company who formally worked it there extensively. It is here 24 feet thick, and extends for a mile and a half, when it becomes split. At Solomon's Gap, south of Wilkesbarre, it is 16 feet in thickness, and at Pittston and Scranton 14 feet. On the north or west side of the valley it is divided into two seams, known

as the Bennett and Cooper, each being six or eight feet thick. At Wilkesbarre there are five workable seams above the Baltimore vein. Of these, the third, in ascending order, called the Hilman, is extensively worked, and is six to nine feet thick. What is known as the Pittston-checker vein is above the Hilman. This and the 14-feet seam are both worked about Pittston.

There is a great variety of opinion among the miners and coal-operators as to the identity of these different coal-seams; and the great changes they undergo, as before described, afford abundant room for errors and conjectures. With the progress in mining, more accurate conclusions will be attained.

The total production of the Wyoming and Lackawanna Valleys, or the third coal-field, in the year 1873, was 10,047,241 tons, carried by nine railroads and one canal; or 51 per cent. of the whole production, which, by Mr. Bannan's statistics, was 19,585,178 tons of anthracite. Since the opening of the trade, this region has produced 97,780,855, and all the regions 257,062,601 tons.

THE PROPRIETORS.

A very natural inquiry now arises as to who are the owners of all these 472 square miles, or 302,080 acres of anthracite coal. The design of this book is to record what is of permanent interest and importance. In this country, property changes owners very rapidly, as we have no laws of primogeniture, and no entailed estates. A list of coal-operators for this year would not answer for next. But another system prevails, by which large estates are accumulated, and remain permanently under a single management. There are incorporated companies, established under the laws of the State for the purpose of building canals and railroads, or for buying and owning coal-lands, mining the coal, carrying it to market, and selling the same; and in some cases they are authorized to buy and deal in coal, or, as is now quite usual, one corporation will be authorized to do all of these things, or any of them. After accumulating sufficient capital, these companies invest their surplus money in buying the stock of other coal companies or other railroad companies in Pennsylvania, New Jersey, or New York, and extend their operations to distant cities and States, chiefly with a view to securing, ex-

tending, and increasing the market for their coal. The magnitude to which these companies have grown would have been altogether incredible in the days of small things in the beginning of the coal-trade.

To give an inventory of the great possessions of these gigantic mining companies would be useless; as a company owning twenty coal-breakers when this is written may, before it reaches the reader, own fifty, so rapid is the absorption of the property of individuals going on. For example, in the year 1871 a company called the Philadelphia & Reading Coal Company, which is generally understood to be identified with the Philadelphia & Reading Railroad Company, commenced the purchase of collieries and coal-lands in the first or Schuylkill coal-field, and has already become the owner of nearly all of that region and the Mahanoy, with large possessions in the Shamokin. The Lehigh Valley Railroad Company has found it necessary to abandon its original policy of being exclusively a carrier of coal, and has purchased large quantities of coal-land in the Wyoming and other regions. The Northern Central Railroad Company has also secured very extensive coal-lands in Shamokin, in the form of stock in a company called the Mineral Railroad & Mining Company. Others of the important railroad companies, and the Pennsylvania Canal Company, are also protecting themselves against a loss of tonnage by buying or obtaining the control of large tracts of anthracite coal-lands.

Among the largest of these coal-mining companies are the Delaware & Hudson Canal Company, the Delaware, Lackawanna & Western Railroad Company, and the Pennsylvania Coal Company. The former was the pioneer in the coal-business, and commenced in 1829, in the northeastern extremity of the Lackawanna coal-field, at Carbondale. But they have passed far beyond that limited sphere, and now own very important tracts of land and collieries in nearly all parts of the third coal-basin, besides railroads leading from Carbondale to Canada.

The Delaware, Lackawanna & Western Railroad Company was originally located at Scranton, where a great city has grown up since 1854, when the first railroad was completed and the first coal sent to market. This company owns very extensive bodies of anthracite lands in both the Lackawanna and Wyo-

ming Valleys, and they have railroads measuring much more than a thousand miles in Pennsylvania, New Jersey, and New York.

The Pennsylvania Coal Company confine their operations more particularly to the mining and selling of coal, their principal collieries being in the vicinity of Pittston. There are also quite a number of other large corporations owning smaller quantities of coal-land, among which are the Pittston & Elmira Coal Company, whose property is near Pittston, the Wilkesbarre & Seneca Lake Coal Company, and the Wilkesbarre Coal & Iron Company. There are also some large individual owners and operators, particularly in the Lehigh basins.[1]

The External Appearance of the Anthracite Regions.

As some readers may never see the anthracite regions of Pennsylvania, the most extraordinary and interesting in the world, some further description of their external appearance is desirable. *The third coal-field* is sometimes improperly called the Lackawanna, and sometimes the Wyoming. The former name properly applies, as already stated, to the upper or northeastern half, and the latter to the lower or southwestern half of the field. In the central and southern part of it we find the famous and really beautiful and fertile valley of Wyoming, which forms a remarkable contrast to the wild and barren appearance of all the other anthracite coal-regions. From Pittston south it is almost twenty miles long, and from four to five miles wide, and was described as follows, by Prof. Benjamin Silliman, in 1830, when it was more beautiful than at present. Large tracts of the coal-lands are now owned by coal companies, by whom the cultivation of the soil is neglected, so that now

[1] There is an annual pamphlet published by Bannan and Ramsey, editors of the *Pottsville Miners' Journal*, called the "Coal Statistical Register," at a cost of about thirty cents per copy, which gives the statistics of the anthracite coal-trade from the beginning, with lists of all the collieries and coal-operators in all of the regions, with many valuable statistics of the bituminous coal-trade, and other interesting information on the subject of coal. Mr. Benjamin Bannan has been the editor of the excellent newspaper mentioned, for more than forty years, and to him we are indebted for the collection and preservation of accurate statistics of the anthracite coal-trade from its origin. Readers desiring details of this character can procure them by sending for the "Register" for the last year.

PENNSYLVANIA.

Year		Wyoming. Tons.	Total Tons.
182		....	365
182		....	1,073
182		....	3,720
182		....	6,951
182		....	11,108
182		....	34,893
182		....	48,047
182		....	63,434
182		....	77,516
182		7,000	112,083
183		43,000	174,734
183		54,000	176,820
183		84,000	363,271
183		111,777	487,749
183		43,700	376,636
183		90,000	560,758
183		103,861	684,117
183		115,387	869,441
183		78,207	738,697
183		122,300	818,402
184		148,470	864,379
184		192,270	[illegible],773
184		252,599	1,108,412
184		285,605	1,263,598
184		365,911	1,630,850
184		451,836	2,013,013
184		518,389	2,344,005
184		583,067	2,882,309
184		685,196	3,089,238
184		732,910	3,242,966
18		827,823	3,358,899
18		1,156,167	4,448,916
18		1,284,500	4,993,471
18		1,475,732	5,195,151
18		1,603,478	6,002,334
18		1,771,511	6,608,567
18		1,972,581	6,927,580
		1,952,603	6,644,941
		2,186,094	6,839,369
		2,731,236	7,808,255
		2,941,817	8,513,123
		3,055,140	7,954,264
		3,145,770	7,869,407
		3,759,610	9,566,006
		3,960,836	10,177,475
		3,254,519	9,652,391
		4,736,616	12,703,882
		5,325,000	12,988,725
		5,990,813	13,834,132
		6,068,369	13,723,030
		7,825,128	15,849,899
		6,682,302	15,113,407
		8,812,905	19,028,125

the visitor may perhaps consider the following as too flattering a description: "Mining districts are rarely rich in soil, the sterility of the surface being compensated by the mineral treasures below. Seldom are both advantages combined; we see it occasionally in some of the coal districts of Britain, and in this respect the valley of Wyoming is particularly happy. It is rich in soil and in the best agricultural advantages. Its extensive meadows are unrivalled in fertility and beauty, and its undulating surface, between the meadows and the mountains, is a fine region for grass and wheat. In a word, splendid and beautiful in the scenery of its mountains, rivers, fields, and meadows; rich in the most productive agriculture, possessed by the still surviving veterans and by the descendants of a high-minded race of men; full of the most interesting historical associations, and of scenes of warfare where the precious blood of fathers, husbands, and sons, so often moistened their own fields—the valley of Wyoming will always remain one of the most attractive regions to every intelligent and patriotic American.

"Its form is that of a very long oval or ellipse. It is bounded by grand mountain-barriers, and watered by a noble river and its tributaries. The first glance of a stranger, entering at either end, or crossing the mountain-ridges which divide it, like the Happy Valley of Abyssinia, from the rest of the world, fills him with the peculiar pleasure produced by a fine landscape combining richness, beauty, variety, and grandeur. From Prospect Hill, on the rocky summit of the eastern barrier, and from Ross Hill, on the west, the valley of Wyoming is seen in one view as a charming whole, and its lofty and well-defined boundaries exclude more distant objects from mingling in the prospect. Few landscapes can vie with the valley of Wyoming. Excepting some rocky precipices and cliffs, the mountains are wooded from the summit to their base; natural sections furnish avenues for roads, and the rapid Susquehanna rolls its powerful current through a mountain-gap on the northwest, and immediately receives the Lackawanna, which flows down the narrower valley of the same name.

"A similar pass between the mountains on the south gives the Susquehanna an exit, and at both places a slight obliquity in the position of the observer presents to the eye a seeming

lake in the windings of the river, and a barrier of mountains apparently impassable

"From the foot of the steep mountain-ridges, particularly on the eastern side, the valley slopes away with broad sweeping undulations in the surface, forming numerous swelling hills of arable and grazing land; and, as we recede from the hills, the fine flats and meadows, covered with the richest grass and wheat, complete the picture by features of the gentlest and most luxuriant beauty."

S. A. Packer, in his report to the Legislature, describes the Wyoming and Lackawanna Valleys as follows: "While the first and second coal-fields present a thin, barren, sterile soil, small portions of it only being susceptible of cultivation, the third field presents a rich, deep loam, embracing the beautiful and fertile valley of Wyoming, one of the most productive and excellent agricultural districts in Pennsylvania. Alike rich in its agricultural productions as abundant in its mineral treasures, the same acre of land may furnish employment for both the agriculturist and the miner. While the farmer is occupied upon the surface, at the handles of the plough, in preparing the rich soil for its seed, or the field waving with rich luxuriance bends before the sickle, the miner, like the antipodes of another region, may be actively engaged in the interior beneath his feet, in mining and bringing forth the long-hidden treasures of the earth. The different branches of industry, therefore, may here not only be placed side by side, but literally one on top of the other. It has the appearance it would present if the contents of some vast lake above had been emptied into the Wyoming Valley, thus covering the coal formations with its present rich alluvial deposit. The alluvial soil is found to extend some distance up the valley of the Lackawanna. The soil toward the lower end of Wyoming Valley, as at Shawnee Flats, is finer or of a more loamy and sandy nature, while farther up, as between Kingston and Pittston, where the less buoyant particles of the sediment may be supposed to have first settled, the deposit is more gravelly and stony. Advancing up the Lackawanna, the soil gradually becomes thinner until we reach Carbondale, where there is not the slightest appearance of alluvial soil, and where the natural face of the country assumes a char-

acter similar in all respects to that of the first and second coal-fields."

The Susquehanna River has its source in the interior of the State of New York, more than 200 miles above Pittston. A valley has been formed for its passage, by the action of water, and gradually deepening as it passes south. Wyoming Valley is indebted for its fertile soil to the material borrowed from the Chemung group north of it, and which was swept into its deep sandstone basin, levelling up its anticlinal ridges in the river-flats during the drift period or by the flood of water, not of the present river, but of the running off of the ocean as the continent was elevated, or as the water subsided in some change in its level. The argillaceous shales of this Chemung group farther north are 1,200 to 1,400 feet thick, and form the best agricultural lands in Bradford County and all Southern New York. But for this water transportation of soil which fertilized the valley, it would have been as barren and dreary a wild, and as unfit for any of the purposes of man, as the Lehigh Mountains at Eckly and Jeddo.

The Lackawanna Valley, as before stated, is very much inferior to the Wyoming in point of beauty, and the soil is comparatively sterile. It has an undulating surface, forming smaller valleys within the greater outside boundaries. These for the most part, especially from Oliphant to Carbondale, are barren hills and ridges covered with bushes, very little better for agricultural purposes than the Lehigh and Mahanoy country. But such has been the great and rapid development of its mineral wealth in the mining of coal and the manufacture of iron, that the busy city of Scranton has sprung up within a few years, besides a number of smaller places, and the whole valley from Pittston up to Carbondale presents a most cheering scene of activity and incessant industry, above and below the ground, by day and by night. If the Lackawanna has not beauty and romance, it has, in common with the Wyoming Valley, what is far better, the substantial realities of life. Some one has said that the saddest sight in the world is a poor man begging in vain for work. On the other hand, happy is the country whose industrial interests are prosperous, and which always offers good wages and plenty of employment. The many noble

mines, railroads, blast-furnaces, rolling-mills, and the numerous branches of business they here bring with them, show what can be done in developing the resources of a country by the capital, enterprise, and perseverance of associations of individuals.

Passing out of the Wyoming Valley toward the second and first coal-fields by either the Lehigh Valley or the Lehigh and Susquehanna Railroad, getting a fine view of the valley as we cross the mountain, we find a region extending from the Lehigh River on the east to the Susquehanna River on the west, about 100 miles in length, including these two coal-regions, which cannot be surpassed for its wild and barren scenery. All soils are supposed to have been formed by the decaying and decomposition of the rocks. Now, in the anthracite regions there are formations of very coarse sandstone, and conglomerate rocks of great thickness, which in the times of geological convulsions formed the strong casket which preserved the black diamonds from destruction. But their hardness and the absence of lime and clay, in these as well as in the red sandstones and shales beneath, rendered them unfavorable to the formation of a fertile soil. Hence you may travel for miles in the Schuylkill, Mahanoy, and Lehigh coal-regions, and the country adjacent, without seeing a productive farm, a green field, or a single sheaf of wheat. For a long time before the discovery of the coal, it must have been a matter of wonder what such a wilderness country was made for, and but for that discovery it would be uninhabited to this day. Here and there some feeble attempt at farming has been made, but with little success, for few signs of crops are visible. Far as the eye can reach from the summit of any of the mountains are the same barren soil, the same rude mountains, and deep, narrow, stony valleys, covered with scrubby oaks and other bushes. All the valuable timber along the railroads and about the coal-works has been cut, and the country is studded with the limbless, charred trunks of hemlock-trees, which add greatly to the forbidding aspect of this desolate-looking country. Even in the immediate vicinity of some large towns in these coal-regions, containing several thousand inhabitants, there is not even an acre ot pasture-land to be seen, no fields of grain or grassy hill-sides, meadows, or orchards, not even fenced fields, for the land is not

worth fencing. It is only in highly-favored places or by means of great labor, and perhaps by the importation of better soil and careful cultivation, that a spot can be prepared for a flower-bed or a garden.

The numerous coal-works, of which there are hundreds, do not add any thing to the beauty of the landscape, for this is altogether a utilitarian region. After seeing one or two of these high wooden structures called breakers, you have seen

FIG. 3.—ANTHRACITE COAL-BREAKER.

COLLIERY BUILDINGS.

A. Headhouse, directly over Mouth of Shaft, where the Coal is dumped.—B. Lump-coal Shute.—C. The Portion enclosing the Breaker.—D. Wing containing Screen.—E. Engine-house.—F. Shop.

them all. Many of them are only half covered, exposing their skeleton-like trestle-works, the whole vast structures blackened with coal-dust and every one accompanied by its huge pile of *culm*, or coal dirt and slate, indicating by its size the quantity of coal that has been produced from the mine. This may well be called the black country. Some of these piles of refuse fine coal are of mountain-size, and the beauty of Wyoming Valley itself is in danger of being destroyed by the heaps of this rubbish thrown out of the coal-mines. In the location of anthracite coal-works it is an important consideration that provision be made for disposing of the vast quantities of fine coal formed by the wasteful process of breaking up the large masses of coal by passing them between two strong iron rollers armed with powerful teeth to reduce them to the various sizes required for different uses. (*See* Plate on page 61.)

But to the eye of practical science these rocky hills and this pebbly, barren soil, with these undulating strata of conglomerate rocks, afford the greatest interest. They are composed of the ruins of some quartz formation which existed in former ages. By what force was it broken into fragments, and how much time was required to wear and grind off the sharp edges and corners and reduce them to the smooth round pebbles which we now see, from the size of a mustard-seed to that of an orange, and to cement them together into the vast stratum, which in some localities is more than 1,000 feet thick? As has been already said, there is no perfect coal-field to be found; only fragments have been left to us, and this great, hard, underlying rock forms the basins in which parts of it have been preserved, and these barren mountains in and around the coal-regions, with the coal-beds which they have saved for us, are but the remains of the much larger formations which have been destroyed.

We can well excuse the want of beauty here, for beneath that barren soil and under those frowning mountains lies buried greater real national wealth than all the glittering mines of California. Unfruitful as may be the soil in these coal-regions, we find here that man lives not by bread alone, for there is here a teeming population who "sow not, neither do they reap." Deep down in the bowels of the earth thousands

of dusky-looking miners toil on in their murky caverns by the light of their little lamps. They know no night nor day, in

POCKETS.

Coal Breaker and Screens.

POCKETS.

Fig. 2.

choosing their hours of labor, uncaring for wind or weather, summer or winter, which are all the same to them; and while procuring fuel for others they need none themselves, for the temperature of their workshop is always the same. There may be to some eyes more interesting spectacles, but certainly there

are few better things for mankind than a branch of productive industry like this, furnishing honest and well-paid employment to a great multitude of men.

The foregoing picture of the country between the Lehigh and Susquehanna, occupied by the first and second coal-fields, does not apply to some of the cultivated valleys surrounding them, which are below the coal-measures; and the exterior appearance of the bituminous coal-regions farther west is also altogether different. Immediately south of the anthracite coal-region, after passing through the Blue Mountain, which is next outside of the double frame or boundary of the coal-regions, we come into the great and fertile Cumberland, or Kittatinny Valley, which extends 1,500 miles in length, and from 10 to 20 in width, across the States of New Jersey, Pennsylvania, Virginia, and Tennessee, following the Alleghany coal-field throughout. Its inexhaustible limestone soil makes it the great food-producing region, while its deposits of iron-ore and limestone, so near the great supplies of fuel, make it, in Pennsylvania, along the lower Lehigh River, our greatest iron-manufacturing region, not to mention its other minor productions. "All Southeastern Pennsylvania, owing to the absence of the harder species of rocks and coarse sandstones, and the presence of limestone and other softer rocks, presents a variety of pleasing scenery, possesses a fertile soil, and has been justly called the garden of the Atlantic slope."

The Sullivan County Region.

Taking leave of the anthracite region of Pennsylvania, producing the ordinary hard anthracite coal, we pass westwardly and northwestwardly over an intermediate space between that and the bituminous coal-region of about 40 miles, in which no coal is found except the semi-anthracite basin in Sullivan County, Pennsylvania, on the head-waters of Mahoopeny and Loyalsock Creeks, and which is in the first of Rogers's six coal-basins of the great bituminous coal-field.

According to Prof. Lesley's topography, the first of the five great northern finger-points of the Alleghany Mountains begins in the southeastern part of Susquehanna County. Like all the

others, it is a flat-topped mountain 1,000 feet high, with the coal-formations on its summit, laid down on top of the Catskill group, which forms the mountain-base of the anthracite regions. The southeastern escarpment or slope of the Alleghany runs from the starting-point mentioned, southwestwardly to the North Branch of the Susquehanna River near Tunkhannock. From this point it runs nearly straight south 63 degrees west 40 miles, and is called the North Mountain. It is a little west of the front margin of this portion of it that we find this, the first of the bituminous coal-basins of Pennsylvania. But the influences which converted the coal of Wyoming and Lackawanna into anthracite had not yet entirely lost their power, and the coal here found is anthracite, but of a soft, free-burning kind, showing in a beautiful manner the gradual progress from the harder species of coal through all the intermediate stages, so far as samples from each locality are preserved for our use. The Sullivan anthracite or semi-anthracite is a peculiar species of coal which, lying midway between the anthracite and semi-bituminous regions, possesses precisely the character which its situation requires, having the fracture and somewhat the appearance of semi-bituminous coal, but burning in all respects like anthracite of a very pure, soft variety, and it possesses this valuable property, that the fire never goes out until the coal is entirely consumed. It is a surprising illustration of the uniform gradation in the character of our coals in a northwest and southeast direction. In addition to the general uses of anthracite coal for domestic purposes, from its peculiarities it may be destined to fill some important place in the useful arts. The coal-seam has a good workable thickness, and affords opportunity for cheap mining. Its far northern position, with good railroad grades to the Western New York market, gives the region important advantages. The Sullivan anthracite began to find its way to market in 1871, by the Sullivan & Erie Railroad, which connects the mines with the Pennsylvania and New York Railroad, an extension of the Lehigh Valley Railroad, at a point near Towanda.

It will hereafter be seen that this first coal-basin passes in a southwestern direction along the valley of the West Branch, but destitute of coal-seams, except in isolated patches, until it

crosses that river, where it develops into importance in the semi-bituminous coal of the Snow-shoe, Phillipsburg, and Johnstown country, and thence extends its two branches in Somerset County to the southern line of the State.

In answer to the important question as to the existence of anthracite coal elsewhere than in Pennsylvania, it may be here stated that, although this favorite species of fuel in Pennsylvania is carboniferous, yet anthracite does not belong to any particular geological age, but is produced by the transformation of fossil fuel of any kind. There is a small coal-field near Santa Fé in New Mexico, which a volcanic overflow resting on a bed of lignite, elsewhere of no value, has converted into anthracite coal. There is a similar instance in the British possessions on Queen Charlotte's Island, on the Pacific coast. At Los Bronces, in Sonora, Mexico, beds of Triassic coal are converted by local volcanic action into anthracite of fair quality. The coal-field of Arkansas contains one thin bed of semi-anthracite coal. These are the only beds of anthracite as yet discovered outside of Pennsylvania, Rhode Island, and Massachusetts, and they are probably not extensive or likely to be of great importance. It is not impossible that others may yet be discovered in the far West. It is well known that there is anthracite in Wales, also in Ireland, and in France, but it is nowhere mined on the large-scale or sent abroad to market. An account of these deposits is given in the following chapters. With these and other unimportant exceptions, it may be said there is no other good, hard anthracite coal now known; certainly there is not a single coal-breaker elsewhere in the world than in the northeastern part of Pennsylvania.

Reduced, by permission, from Frenzeny's large picture in *Harper's Weekly*.

THE MINERS' PAY-DAY.

III.

RHODE ISLAND AND MASSACHUSETTS.

The following account of the anthracite coal-field of Rhode Island and of Bristol County, Massachusetts, is taken from a report made to the Legislature of the latter State by President Edward Hitchcock in 1853. It had long been known that anthracite existed in Rhode Island and the adjoining southern part of Massachusetts, it being first noticed in 1760, but in consequence of some peculiarities, both in the coal and the rocks, geologists have been slow to settle its exact position in the geological scale. The same has been the case with some coal-deposits in Europe, the culm or anthracite deposit, for instance, of Devonshire. So for a long time the anthracite of Pennsylvania was thought to belong to an older deposit than the true coal-measures. But the progress of science has cleared up some of these difficulties, and given us more exact rules for determining questions of this character.

There is a large tract in Bristol County and a part of Plymouth County, Massachusetts, and covering the whole of the island of Rhode Island, and a strip on the west side of Narragansett Bay, embracing not less than 500 square miles, that is a genuine coal-field of the carboniferous age, but that has experienced more than usual metamorphic action. It is so covered with detritus that it is extremely difficult to fix its limits. The discovery of the beds of coal was also rendered very difficult by the deep coating of drift that envelops the whole region, and most of the discoveries of coal have been made quite accidentally. The great irregularities in the thickness of the coal-beds and the plication of the strata have also been serious obstacles.

The metamorphic action to which this deposit and the coal

itself have been subject is twofold, first mechanical, secondly chemical. The mechanical force seems to have operated upon the strata containing the coal, in a lateral direction, so as not only to raise them into a highly-inclined position, but also to produce plaits or folds, such as would be formed if several sheets of paper lying upon one another were taken into a man's hand, and by pressure on the opposite edges were crumpled, so as to form ridges and hollows. In Pembrokeshire, in Wales, the coal is folded in this form, and squeezed into the outer or upper and lower curves of the flexures, while between them the roof and floor of the beds come almost into contact, so that the coal can hardly be traced. The same effect has been produced upon the coal-strata of Massachusetts and Rhode Island, as well as in the great Appalachian coal-field of Pennsylvania and Virginia. The miners are familiar with these irregularities, and they constitute some of the most serious difficulties with which they meet. In the Aquidneck mine, at the north end of Rhode Island, the bed of coal that had been worked in some places is pinched up to a width of not more than one foot or two feet, while in other places it has a thickness of from 10 to 15 feet. Another peculiarity is here noticed, which is difficult to describe intelligibly without drawings; it is this, that the foldings do not run either perpendicularly or parallel to the strike or direction of the strata, but obliquely. Hence when a thick mass of coal is reached, it passes into the earth between the strata in an oblique direction, and other expansions as well as contractions of the bed will run parallel to it. This fact will be of some practical value, but perhaps its chief interest lies in its scientific bearings. Another effect of the plicating force has been to shatter the beds and crush the coal, so that, when dug out, it crumbles too much and produces a great deal of fine coal. Sometimes the coal appears as if it had been severely squeezed, and made to slide along between the strata. It is a common impression, among those familiar with these mines, that the force came from the northwest, that is, the rocks in that direction were crowded against those lying to the southeast. But, in the Aquidneck mine, the direction of the folds, which are somewhat southeastwardly, would indicate the pressure either from the northeast or southwest.

The chemical metamorphoses which these rocks have experienced consist mainly in such effects as heat would produce. This coal-basin is in a great measure surrounded by unstratified rocks, such as granite and syenite, which all geologists now admit to have been once melted. No examples are seen in which they have sent veins into the coal-strata, a fact that seems to indicate that the latter were not deposited till after the granite and syenite partially cooled. Yet along the margin of this coal-field, especially at Newport, all along the west shore of Narragansett Bay, at Smithfield, Cumberland, Wrentham, Bellingham, etc., we find the slates very much metamorphosed, so as only heat could have done it. It is inferred, therefore, that these slates were deposited while yet great heat existed in the subjacent unstratified rocks, and, although the coal strata may be newer than the metamorphic slates, yet they also show a greater degree of induration, and in some instances more of crystallization, than is common in undisturbed coal-fields; and cross-seams or divisional structures are also more common than usual. These, too, are now usually referred to the action of heat. The coal also from this basin has greater specific gravity than most anthracite, bearing a proportion to the Pennsylvania anthracite of 1.75 to 1.55. It has a tendency more than usual to break into cuboidal fragments, and has more the shining aspect of crystalline minerals. In some of the mines the metamorphic action has been so great as to obliterate all traces of organic remains. This is so remarkably the case at a coal-bed seven feet thick in Worcester, that no trace of vegetables has ever been discovered there, and the anthracite has a still more stone-like aspect, is heavier than that from Rhode Island, and is partially converted into plumbago. Yet even this most geologists would not hesitate to pronounce a genuine coal-formation. But in other parts of the Bristol and Rhode Island coal-field vegetable remains are found in connection with these coal-beds, which make it almost certain that they belong to the coal-measures of the carboniferous system, such as calamites, an ancient reed with a pointed stem and fluted surface, and stigmaria, which are the roots of trees which grew in the clay soil below the coal. These to the geologist are the most decisive arguments on this subject. For it is a principle, now settled

beyond controversy, that each geological formation has its peculiar organic remains, and the coal-formation contains those that distinguish it from all other deposits. The rocks of the region correspond essentially to those of the coal-measures, being a dark-colored slate, often much indurated and more or less charged with carbon, lying in immediate contact with the coal, especially beneath it, with its surface highly glazed as if by heat or friction; also coarse light and dark-gray sandstones, coarse gray conglomerate, and other varieties, which can be identified with those of other coal-fields, though more metamorphosed than is common. The evidence is too strong to resist, that this deposit in Rhode Island and Massachusetts is a genuine coal-field of the carboniferous series, of the same age as the great coal-deposits in our own country, in Pennsylvania, West Virginia, Ohio, Michigan, Illinois, and Iowa; and of those of England, Scotland, France, and Belgium. The only difference seems to be that this is a metamorphic coal-field. And the tendency to a northeast and southwest direction in the beds, as well as the high dip, lead strongly to the conclusion that it is only a detached portion of the great Appalachian coal field which stretches through the Middle States.

The following tabular statement presents in a small space the leading facts respecting the principal localities where coal has been discovered and mined in this field:

LOCALITIES.	No. of Beds.	Thickness of Beds.	Strike of Beds.	Dip.
Mansfield Centre, Mass....	1	A few inches.	N. E. and S. W.	N. W. large.
" Hardon, "	7	10 feet.	" " "	53° N. W.
" New, "	13	7 feet max.	" " "	30° to 70° N. W.
Wrentham, "	1	....	E. and W.	45° N.
Raynham, "	1	3 feet.	N. 50° E.	45° S. E.
Cumberland, Rhode Island.	2	15 to 23 feet.	N. E. and S. W	45° W.
Valley Falls, "	5	6 to 9 feet.	N. 50° to 60°	E. 30° to 45°.
Providence, "	1	10 feet.	N. W. and S. E.	45° N. E.
Bristol, "	1	....	N. E.	48° N. W.
Portsmouth, Case's "	3	18 feet max.	N. E. and S. W.	40° to 90° S. E.
" Aquidneck, "	3	2 to 20 feet.	N. E.	28° to 35° S. E.

The Portsmouth or Case's mine, situated in the northeast part of the island of Rhode Island, was opened in 1808, which was earlier than the Pennsylvania mines were explored. At that time the mode of burning anthracite was not known, the coal was not sought after, and the mine was abandoned. It

was resumed in 1827, again abandoned, again opened in 1847, and again abandoned. Three beds were discovered, all of workable thickness, and the one last wrought was 13 feet thick.

At the Aquidneck mine, two miles west of the above, three beds occur, varying in thickness from 2 to 20 feet. It was worked in 1853 to the depth of 623 feet, and thence six gangways extended 844 feet each. Large sums of money appear to have been spent at different times in different localities, but, owing to the causes already mentioned, in giving the description of the coal, and to its being found in a form so unfavorable for mining, these enterprises have invariably resulted in disappointment. A gentleman in Newport, familiar with the business, informed Prof. Chas. T. Jackson, who made the geological survey of Rhode Island, that upward of $40,000 were spent in the Portsmouth mine, a large sum for those days. He describes the coal as anthracite and very curiously checked by natural joints leading to a rhomboidal structure, this being the result of an imperfect crystallization effected by heat at the epoch of its elevation from a horizontal position. Masses of coal of considerable magnitude may be easily broken off, but they divide readily into rhomboids an inch or two in diameter. The chemical analyses of the coal show from 77 to 84 per cent. of carbon, from 7 to 10 of water and volatile matter, and from 5 to 6 of ashes. Prof. Jackson's analyses of the coal from the mine at Mansfield, Massachusetts, gave 90 to 92 per cent. of carbon, 2 to 4 per cent. water and volatile matter, and 4 per cent. of ashes. Of course, there is no trade in this Massachusetts and Rhode Island coal, and so long as better qualities of coal are produced and sold at moderate prices, or until some special use or market is found for this peculiar coal, it cannot be regarded as of any commercial value. The largest production has been from the mines about ten miles north of Newport, where the whole quantity mined to the year 1856 was 60,000 tons.

The formation, as has been said, reposes on a coarse conglomerate, which rests immediately on granite or hornblende rocks of the primitive series. This, however, as well as rocks of a similar appearance, in the East Virginia and North Carolina coal-fields, is now thought by geologists to consist of Silurian

and Devonian rocks dislocated and altered, or metamorphosed by volcanic or other agencies which have destroyed all organic remains, and given them the appearance of primitive rocks. Walter R. Johnson, in his researches on American coals, gives us the following further interesting account of the Rhode Island coal-field:

"The near proximity of igneous agencies appears to have exercised an important influence not only on the position, but on the present character of the anthracite of this formation; for, while it has thrown the beds into a highly-inclined position, it has expelled the last vestige of vegetable matter, decomposed the sulphuret of iron, and changed the color in some of the beds to a nearly steel blue. The vegetable impressions are in these cases to a great extent obliterated, and the traces of them only appear at the surfaces of deposition. In other beds, the impressions are more perfect, and their genera and species are more readily made out.

"An idea has been formerly current that the coal-formation of Rhode Island and Massachusetts is of a more ancient date than those of Pennsylvania, but the identity of fossil remains seems to determine the geological period of both to be the same. And in this we have analogies sufficiently numerous in our own country to induce us to believe that all the coal-formations are essentially contemporaneous, and that, whether they rest on granite, as in Rhode Island and Massachusetts; on the older members of the secondary, as in the anthracite fields of Pennsylvania; or on the mountain or cliff limestone of the Western States, the coal-series has everywhere been the product of the same period in the history of our planet, which was highly prolific in vegetable life, of which the remains were deposited on whatever member of preceding formations was exposed in a condition to receive them."

A remarkable instance of this is shown in a single coal-field, that of Illinois, which in its northern part rests on St. Peter's sandstone, a member of the Potsdam or lowest in the series of fossiliferous rocks; and as you pass southward, the coal-formation rests successively on each of the formations up to the Chester limestone, its true base, where all the formations are complete. This was caused by the gradual rising above the

surface of the water of the northern part of the area during the formation of those lower rocks.

"The anthracite of Rhode Island appears to have been subjected not only to a high temperature, but also to intense pressure, and to have been much comminuted by the friction of one member of the formation sliding over another in the uptilting which the strata have evidently undergone. The coal being in all such cases more tender and friable than the sandstone, slates, and limestones, becomes the unguent in the joints of stratification, and the results of its power to facilitate the motions of the strata as they are partially folded is first a pulverulent portion in contact with either the top or the bottom rock of the bed; second, a high polish imparted to some of the sliding surfaces of the more durable coal; third, an irregularity in the thickness of the coal-beds, the indentations of the upper and lower rocks being not infrequently found opposite to each other, forming thick places in the coal-seam, and containing much of the broken material which has been displaced from the parts where the prominences of the rocks come nearly in contact and almost shut up the seam."

He adverts to the facts that, owing to the great amount of drift or diluvial matter covering the coal-formation, its limits have not been traced with much precision, the mining operations are in general very troublesome, and expensive for the same reason, as well as on account of being carried on below water-level, in irregular, uncertain seams; and worst of all that very little of the coal hitherto obtained has been of merchantable quality.

Daddow and Bannon, in "Coal, Iron, and Oil," show very conclusively that "the various attempts to develop these New England coals have all resulted in failure, not from the want of means and experience, but because the beds were too unreliable and irregular to permit the production of coal with economy, or in competition with mining operations in Pennsylvania."

IV.

ANTHRACITE COAL NEAR SANTA FÉ, NEW MEXICO.

The occurrence of anthracite coal in workable beds in the Western Territories, near the gold and silver districts, is of such great importance that the following detailed description of it is given in full from R. W. Raymond's Report, as United States Commissioner of Mining Statistics of the States and Territories west of the Rocky Mountains, for the year 1870.[1]

The anthracite mines of New Mexico are at the Old Placer Mountains, or near the northwestern foot-hills of that range, about 23 miles southwest of Santa Fé, and respectively four and a half and six miles from the mining-town of Real de Dolores.

It is well known that anthracite beds occur in almost all formations, though they are mostly found in the older rocks of the paleozoic era, and always in localities where these rocks have either been considerably disturbed by eruptions and upheavals subsequent to the deposition of those strata, or where hot, molten masses, though they have not disturbed the original stratification of the neighboring rocks to any considerable extent, have, at a former period, exerted metamorphosing influences on them. Thus the fact has been satisfactorily established in many coal-beds of great extent that they may in one locality consist of a true anthracite, while in another locality, remote from the causes of metamorphism, the same beds, determined as such by the enclosing strata and the fossils found in them, may contain bituminous coal or even lignite.

[1] "Mines, Mills, and Furnaces," by Rossiter W. Raymond. Published by J. B. Ford & Co., New York, 1872.

An entirely analogous case is presented by the anthracite beds of the Placer Mountains.

True anthracite has a specific gravity of 1.4 to 1.7, its hardness is 2 to 2.5, and it contains 85 to 93 per cent. of fixed carbon and volatile matter, after drying, 3 to 6 per cent. It is amorphous, of conchoidal fracture, brittle, has a sub-metallic lustre, iron-black to grayish and brownish-black color, and, when pulverized, forms a black powder. It ignites with difficulty and at a high temperature, but when ignited produces an intense heat. The coal from the coal-mines to be described in the following account presents all these qualities, and there is, consequently, no doubt that it is really anthracite.

At present two mines, one and a half mile distant from each other, are opened by the New Mexico Mining Company. A wagon-road leads from Real de Dolores in a northwestern direction around the foot-hills of the Old Placer Mountains to the new anthracite mine. Before reaching the mine the road leads through a ravine parallel to those where the coal-bed is exposed, and about 250 yards distant from them. Here the outcropping rocks consist of nearly horizontal layers of massive sandstone, which is covered with an overflow of porphyry. A dike of the same rock is found on the lower side of the croppings of the Cunningham gold-mine, from where it has been traced with slight interruptions over six miles to the old anthracite mine, forming a cap on the massive sandstones of the coal-bearing formation. The new mines are situated at the junction of two small ravines, forming a larger one, which descends gradually, first in a northeastern, then in a northern direction, toward Galisteo Creek, two and a half miles distant from the mines. The lower wall of the coal-bed is nearly level with the bottom of the *arroyo;* and, as the dip is about 15° southeast toward the ravine, the position of the bed is certainly an exceedingly favorable one for opening and working. It has been opened in two different localities on the eastern side of the south branch of the ravine, at the junction of the two smaller ones, and on the western side of the same branch about 50 feet south of the first opening. The first one follows the dip of the bed for a distance of about 35 feet; the incline, five feet high by five feet wide, is excavated in solid anthracite, and

shows the bed to be of great regularity. The following strata accompanying this coal-bed are exposed to view in this locality, from the bottom of the ravine to the top of the hill:

Carbonaceous shales	1 foot.
Anthracite	5 feet.
Carbonaceous shales	1 foot.
Indurated clay	4 feet.
Laminated argillaceous sandstone, containing fossils	25 feet.
Massive sandstone	100 feet.

In the second locality the coal is opened by three tunnels, two 25 feet long and one 40 feet long, showing the same strike and dip of the bed as the incline. The anthracite, however, is only four feet thick, while the thickness of the shale varies from three to four feet.

About 280 tons of coal have been taken from this mine. It shows all the qualities of a true anthracite, contains 87.5 per cent. of fixed carbon, and, when burning, shows only the short, blue flame of carbonic oxide. The steam-boiler of the engine propelling the New Mexico Mining Company's stamp-mill has been successfully heated by it. A hundred pounds brought to Santa Fé were used by Mr. Bruckner in his assaying-furnace, in order to test the heating powers practically. He found that a white heat was reached in a very short time, and that this heat lasted about three times as long as that produced by an equal weight of charcoal. As the material does not coke in the least, it is evident from this test that it is perfectly adapted to use in blast-furnaces, though it will require a higher pressure of blast, on account of its density, than charcoal or coke. As far as its application for all practical purposes is concerned, it is undoubtedly fully equal to Pennsylvania anthracite, and really the best fuel discovered so far in the West.

The second coal-mine is situated about one and a half mile southwest of the one just described. Between the two mines exists a bed of excellent fire-clay, some of which was tested by Mr. Bruckner, in Santa Fé. He made a scorifier out of it, and smelted lead and borax in it in the hottest anthracite fire. It neither cracked, nor was it attacked in the least by the flux, so that this test speaks well for its use as fire-proof material in furnaces.

Between the fire-clay and the following sandstone stratum a bed of iron-ore is found. Both carbonate of iron and hematite are present. Ores of this, as well as bowlders of magnetic iron-ore, and large deposits of the same, abound in the mountains of the Old and New Placer. Thousands of tons of large bowlders of great purity can be collected, for instance, near the old anthracite mine, away from the different extensive deposits of magnetic iron-ore which occur in the same locality.

The second anthracite mine, spoken of above, is opened by a tunnel 90 feet in length, driven into the coal-bed near the entrance of a steep ravine, the sides of which are nearly perpendicular. It is started near the bottom, and on the west side of this ravine, rising with the dip of the strata, which, as in the locality spoken of first, is 15° to the east. The following succession of strata, commencing at the bottom of the ravine, is visible: Anthracite, two feet; slate, ten inches, diminishing toward the breast of the tunnel; anthracite, one foot six inches; alternating layers of shale, iron-ore, and sandstone, varying from five to nine inches in thickness; laminated argillaceous sandstone, containing fossils; and twelve feet of massive sandstone, overflowed by felspathic porphyry. The latter rock forms the east bank of the ravine from top to bottom. About 100 tons of anthracite of an excellent quality have been taken out and are lying on the dump. Long exposure to the atmosphere through summer and winter has not altered its compactness in the least. It is of jet-black color, and contains 88 per cent. of fixed carbon, and 5 per cent. of ashes of a brick-red color.

Although roving bands of hostile Navajoes visit this locality sometimes, and even have their usual camping-place at the coal-mine, the splendid opportunity offered here for procuring a cheap and superior fuel for the surrounding mining-districts will undoubtedly be more extensively made use of very soon. For those who intend the erection of metallurgical and especially smelting-works for the beneficiation of the more rebellious gold and silver ores, and also for copper and iron smelting establishments, the occurrence of those anthracite beds is of the utmost importance, and will no doubt be duly appreciated.

At the south side of the Old Placer Mountains, at a dis-

tance of 10 miles from the above-described coal-beds, an anthracite vein has been opened in the second arroyo east of the rancho near the spring on the Tuerto Dolores. There are two pits of a depth of about six feet. The first one shows the following section: Shale, two feet; anthracite, ten inches; shale, eight inches; anthracite, two feet. The strata course north 37° east and dip 75° northwest. The second pit is located within 100 feet from the first, and contains only a six-inch seam of coal, which contains a great deal of sulphur.

Another coal-bed is exposed near Galisteo Creek, but, as the locality could neither be visited nor a specimen procured from it, its nature and the quality of the coal could not be determined. Indications of coal-oil are said to exist here, as well as two miles north of Santa Fé, where a layer of coal mixed with iron pyrites occurs.

Among the many different localities where coal-veins crop out in this Territory, are the following: On the reservation of the Pueblo Indians, near Taos, at the foot of the Pueblo Mountains; in the Raton Mountains, on the Vermejo River, near Maxwell's, where the beds are six feet thick; on the Purgatoire River, near Las Vegas, at the Rio Puerco, in the San Mateo Mountains, and in numerous places west of Fort Wingate; a large bed also exists near Fort Craig (San Pedro). Most of these beds have been ably described by Dr. John L. Leconte, in his notes on the geology of the survey for the extension of the Union Pacific Railroad, eastern division, from the Smoky Hill River to the Rio Grande. (Philadelphia, 1868.)

Coal has been used to a very limited extent so far. The Vermejo and San Pedro coals are used for blacksmithing, the latter also for domestic purposes at Fort Craig. The anthracite from the Old Placer, it has already been stated, is used for the heating of a steam-boiler. None of the New Mexico coal has, so far, been used for metallurgical purposes, although some of it is very well adapted to such use. No attempt has ever been made to smelt iron, although ores exist in great abundance and of great purity in the immediate vicinity of anthracite coal, and contiguous to fire-clays and limestone.

V.

FOREIGN ANTHRACITE COAL.

As but little is known, in this country, in regard to the anthracite coal produced in England and on the Continent of Europe, the following particulars are here given from the report of the Parliamentary Commission, made in 1871.

Anthracite coal is obtained in England, at Bidwell in Devonshire, at Walsall in Staffordshire, in the western divisions of the South Wales coal-field, in Ireland, and near Edinburgh. Anthracite coal is also found in the coal-fields of France, especially in the departments of Isère, the High Alps, Gard, Mayenne, and of Sarth, and it is also raised in Belgium.

In South Wales anthracite coal was used in 9 furnaces in blast, in 1864, out of 23 built; the quantity of anthracite iron made being 26,565 tons, out of a production of 839,502 tons. The whole quantity of anthracite coal mined was 509,475 tons; viz., 146,000 tons in Pembrokeshire, and 363,475 tons in Carmarthen and Glamorganshire. Of this, 347,000 tons were shipped, and 162,475 tons were used for household purposes, for iron-works, and sent off by railway to be used principally for malting. The principal production of anthracite coal in the kingdom of Great Britain is that in Wales.

It is well known to geologists that the Palæozoic strata of England underwent great movements and denudations after the formation of the coal-measures, especially that one great line of disturbance ran from the south of Ireland, skirting the coast of South Wales, passing south of Bristol, and visible as far as Frome, where the highly-inclined Palæozoic strata are

lost beneath horizontal strata of later date. This disturbance was accompanied by fracture and enormous lateral pressure, which crumpled up the older rocks along the line of strike, and in places along the same line elevated the fractured strata into ranges of hills. In England, the main chain due to this disturbance is that of the Mendip Hills in Somersetshire. These forces affected the strata to a greater or less distance from the line of disturbance, tilting them up at a high angle, which gradually decreases as the distance from the line of disturbance increases. This elevation of the older strata was followed by an enormous amount of denudation, whereby the edges of the strata so disturbed were worn and planed down to such an extent that in many cases masses of strata many thousand feet thick were removed before the deposition of any of the secondary strata commenced.—(Report of Royal Commission.)

This description of the disturbances of the more southern of the coal-fields of England, Wales, and Ireland, will apply to our American Appalachian country, which presents the same common features from New Jersey to Alabama. And as, here in Pennsylvania, the coal found within the influence of the more violently-disturbed strata is anthracite, and that farther northwest is semi-bituminous, and that still farther true bituminous, so we find the same law applies to the character of the coal in the disturbed district of Southern England, Wales, and Ireland. In Wales, the changes are more rapid, opposite sides of the same basin producing anthracite on the south, and bituminous coal on the north, while in America the changes are more gradual. Another point of resemblance is the greater steepness of the north dip, or the dip of the south side of the basins, and next to the source of the disturbance, than that on the north side, which is also a universal rule in Pennsylvania.

No coal has ever been found in England south of the disturbances spoken of, running through Munster, Leinster, South Wales, and Somerset, just as we find none southeast of the more violent of our Appalachian flexures, except some squeezed-up fragments. The existence of coal in the south of England was one of the problems referred to the Royal Commission, and on

which they made the report in 1871. Although the report was in favor of the theory of the existence of coal in that locality, it was in opposition to the protest of Sir Roderick I. Murchison, the most distinguished English geologist. The "Memoirs of the Geological Survey" describe the same series of coal-beds becoming so altered in their horizontal range that a set of beds, bituminous in one locality, is observed gradually to change to anthracite in another. Taking the coal-measures of South Wales and Monmouthshire, we have a series in which the coal-beds become not only more anthracite toward the west, but also exhibit this change in a plane which may be considered as dipping south-southeast at a moderate angle, so that in the natural sections we have bituminous coals on the high grounds, and anthracite coals beneath. This fact is readily observed, either in the Neath or Swansea Valleys, where we have bituminous coals on the south, and anthracite on the north. Though the terms bituminous and anthracite coal have been applied to marked differences, the changes are so gradual that there is no sudden modification to be seen. To some of the intermediate kinds the term "free-burning" has been given, and thus three chief differences have been recognized.

The term culm is applied to an inferior kind of anthracite, only worked for making lime, or for mixing with clay, or to the small pieces of anthracite obtained in working the true anthracite beds, and the same term is applied generally to English anthracite in their parliamentary returns. Anthracite is also called blind coal, glance coal, and Kilkenny coal. An average of several analyses of Welsh anthracites shows 91.5 carbon, 6.7 volatile matter, and 1.8 ashes, showing more volatile matter and less ashes than ours. In Wales, the anthracite coal-seams vary very much in thickness. In Pembrokeshire, the Kilgetty seam is only from 11 to 13 inches thick, and in some parts of South Wales they are as much as 15 feet thick. In Pembrokeshire, veins as small as 11 inches are worked for the coal alone, which is anthracite of an excellent quality, used chiefly for malting purposes and hop-drying, and extending over a very limited area. It is worked in pits where no thick seams are worked, and at 180 yards' depth often containing a large quantity of water. It brings a very large price,

and is near the shipping-point, but it is used to only a very small extent. The product of Pembrokeshire was stated in 1868 to be 134,000 tons a year. The thinnest seams that are worked for general consumption are about two feet three inches, or two feet four inches. The veins worked in the neighborhood of Llanelly exclusively for the coal are about 22 inches thick; the Golden vein is from 22 to 26 inches, the Fiery vein is 36 inches, and so on, up to five feet, which is the big vein.

The dip on the south crop is 16 inches in a yard toward the north, and it is only three inches in a yard along the northern crop toward the south. On the north crop the coals are generally hard and strong, and on the south crop they are generally very soft. Some of the southern seams are from eight to 15 feet thick, and such is the loss from mining by the old pillar-and-stall system, that they only produce 9,000 tons per acre.

There are about 28 to 30 seams of anthracite coal, of which about six are worked. Anthracite coal is very little used, there being but little demand for it. It is of "enormous thickness," to quote the language of the witnesses, and any quantity of it may be had, yet the quantity worked is only "about 400,000 tons a year." It is used for iron-making to a small extent, but not for steam, in England, except locally at the engine-boilers at the pits. It is not sold to any extent, being chiefly used for malting and drying hops, and for burning lime in the neighborhood of the mines. But, even in Wales, the railway communication is now so good that other coals are easily taken to the limestone districts to compete with the anthracite small coal. It is, however, perhaps the best of all lime-burning coals.

Scarcely one-fourth of the coal-field of South Wales is anthracite; there is, however, a very large quantity of this coal. It is the lower series of seams irrespective of depth that is anthracite, according to some of the testimony. None of the small anthracite coal is brought out of the mines, except accidentally, being of no value. The commission reports the South Wales coal-field as containing 32,456,000,000 of tons unmined, besides 4,109,000,000 of tons at a depth exceeding 4,000 feet, or too deep for mining. It embraces 36 per cent. of all the unmined coal in England, Scotland, Wales, and Ireland.

The proportion of this that is anthracite was not definitely ascertained, but is stated in a general way, by a mine-inspector of the region, as less than one-fourth.

In Ireland, the anthracite coal is in the southern part of the island, in Leinster and Munster. In the former, about eight collieries are at work, and in the latter about 12. The returns of 1866–'68 show more anthracite than bituminous coal produced in Ireland, the former being about the amount of the product of one of our Pennsylvania anthracite breakers, viz.: in 1866, 68,750 tons anthracite, and 55,000 of bituminous; in 1867, 78,000 anthracite, and 50,000 bituminous; and in 1868, 74,500 anthracite and 52,450 of bituminous coal. In 1869, the quantity of both was 127,923 tons, showing a very uniform production.

The culm or unproductive anthracite coal-basin of Devonshire, in the southwest part of England, is practically of no importance. The attempts to work the beds have always failed to reward the adventurers with any profit. It is broken up in contortions, and an incredible number of synclinal and anticlinal lines. Its geological age has been a matter of dispute. The anthracite is much mixed up and interwoven with black shales, among some of which are remains of land-plants. The deposits of carbonaceous matter are extremely irregular. The middle or great anthracite bed upon which all the chief workings have been carried on is described as varying from six inches to 14 feet in thickness, the average being about seven feet. The returns are 5,036 tons produced in 1856 and 4,173 tons in 1857. This description of the Devonshire coal-field is what our knowledge of those of Ireland and Wales, farther north on the line of the great disturbances of the region, would have led us to expect as to its value.

Edinburgh used, in 1868, 5,500 tons of anthracite for the manufacture of glass, which is the whole product. There is a great upheaved district of the older rocks, extending from Berwick southwestward, north of which the coal-measures are again found. They are broken up into several distinct fields, partly by the uprising of the lower coalless strata, and partly by the interference of vast masses of igneous or trap rocks (the whin of England), sometimes bedded and at others injected as

dikes. The production of anthracite in such localities is thus accounted for, as the region is also much dislocated by faults and interfered with by igneous rocks.

The Staffordshire coal-field lies along the original margin of the coal-basin in that direction. There are no returns of anthracite produced there. Of the coal used in London only 1,143 tons are anthracite, and that by the Houses of Parliament.

The anthracite trade of England, Wales, Scotland, and Ireland, is therefore less than 600,000 tons, a very small portion of their whole production, which in 1869 amounted to 107,299,634 tons.

VI.

BITUMINOUS COAL.

Characteristics of the Seams and Methods of Mining.

THIS work is not intended to teach technical and theoretical geology, nor the art of mining; but there are a surprising number of persons who have never seen a mine of any kind, and who have very erroneous notions on these subjects. Some general account applicable to all the regions, therefore, appears to be necessary of the form, size, and other characteristics of bituminous coal-seams, and the more simple methods of mining.

There are no veins of coal; for, although that term is very frequently used by miners and others, it is incorrectly applied to coal, and may lead to erroneous conclusions. Coal invariably runs with and parallel to the strata of rock among which it is found; while veins (Fig. 8) are the fillings of cracks or fissures usually running across the strata or lines of bedding of rock, or intersecting them. Coal, on the contrary, is always found in thin layers or seams, from a few inches up to a couple of yards in thickness; the larger beds are exceptional; it is always stratified and found among and between stratified rocks, and is quite as regular as veins are the reverse. (*See* plates, pp. 24 & 137) Several of these seams of coal are usually found above one another and separated by layers of rock of different thicknesses. A seam, then, is a thin layer inserted among the larger layers of a rock and differing from them in composition.

FIG. 8.

Granite Veins traversing Clay Slate, Table Mountain, Cape of Good Hope.

Seams are called beds when they are of considerable thickness,

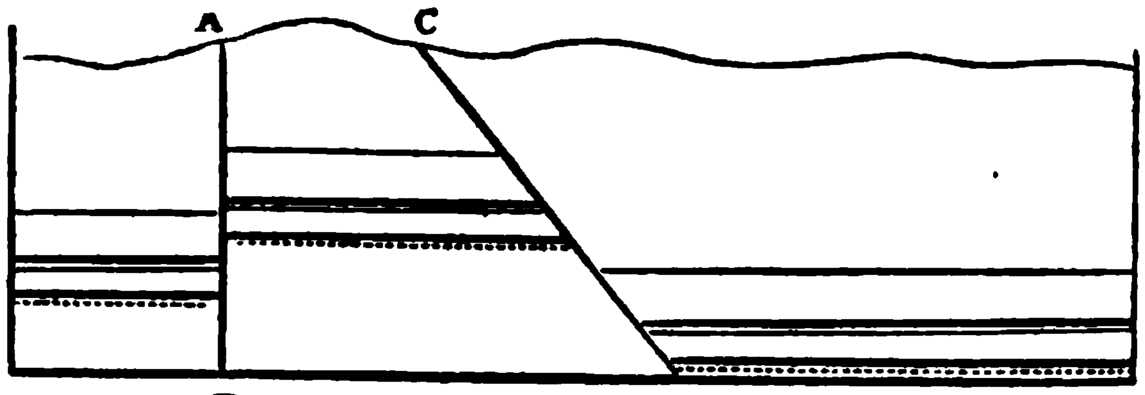
and a layer is a considerable member or bed in a stratified rock. A stratum consists of several layers of one kind, which form a rock as it lies between other kinds; and a formation is a series of strata comprising those which have a general similarity in their fossils or organic remains. Several of these formations when naturally classed together are called a group, and several groups form a system. In reference to time, the terms used are epoch, period, and age; which correspond with formation, group, and system. By a coal field or basin is meant a region of country usually basin-shaped or trough-shaped, that is underlaid by beds or seams of coal.

Coal-seams are like the leaves of a book, for, as you know that each leaf runs through the volume, so as a general rule when you have found a seam of coal and ascertained its strike —that is, the course a level line would run across it if all the covering were removed, and its dip or the course of its greatest degree of descent—you may depend on its running on regularly through the hill or land as far as the ground will permit it to run in that direction. The regularity of coal-seams, when undisturbed or found in their original position, the persistence with which they continue to run in the same direction for long distances, and preserving the same size and peculiarities, is very remarkable. They are much more persistent than the beds of rock with which they are associated; sometimes even a very thin seam, "the rider" as the miners call it, above some larger workable bed, is found to be expanded over the whole extent of the coal-region; and such is the similarity of the seams of coal and their intervals of rock in widely-distant places, that geologists have been enabled to trace and identify them, both large and small, for distances of hundreds of miles.

Of course, this rule is to be considered as applicable in a general way only. The exception is, that, although the coal-seam is generally continuous, it is sometimes broken. The coal-field, instead of being, as we supposed, in one book, is in fact found to be in several volumes, and they are not regularly disposed. The binding of all is the same, the same kind of rock being over the coal and the same under it in each separate field; and the coal itself is the same, but some parts are higher than others, or lying at a different angle to the horizon, or at

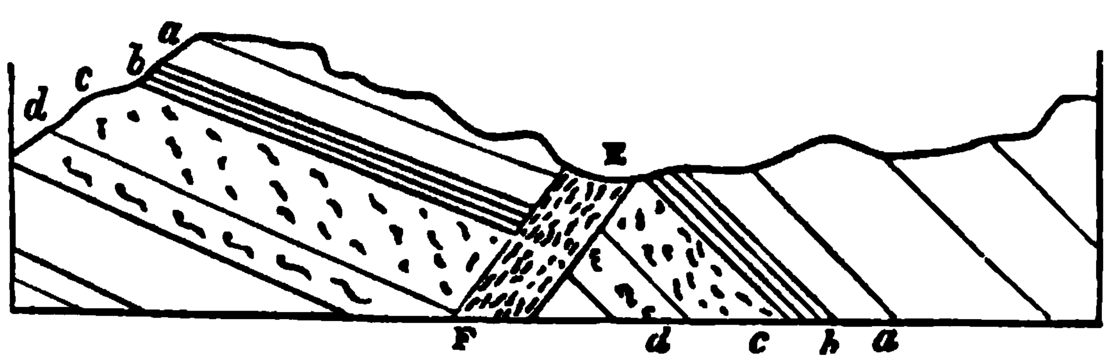
the same angle when the fault is vertical, and, after exhausting the coal in one part of the land, we find no more until we have searched for it on a higher or lower level. These irregularities

Fig. 9.



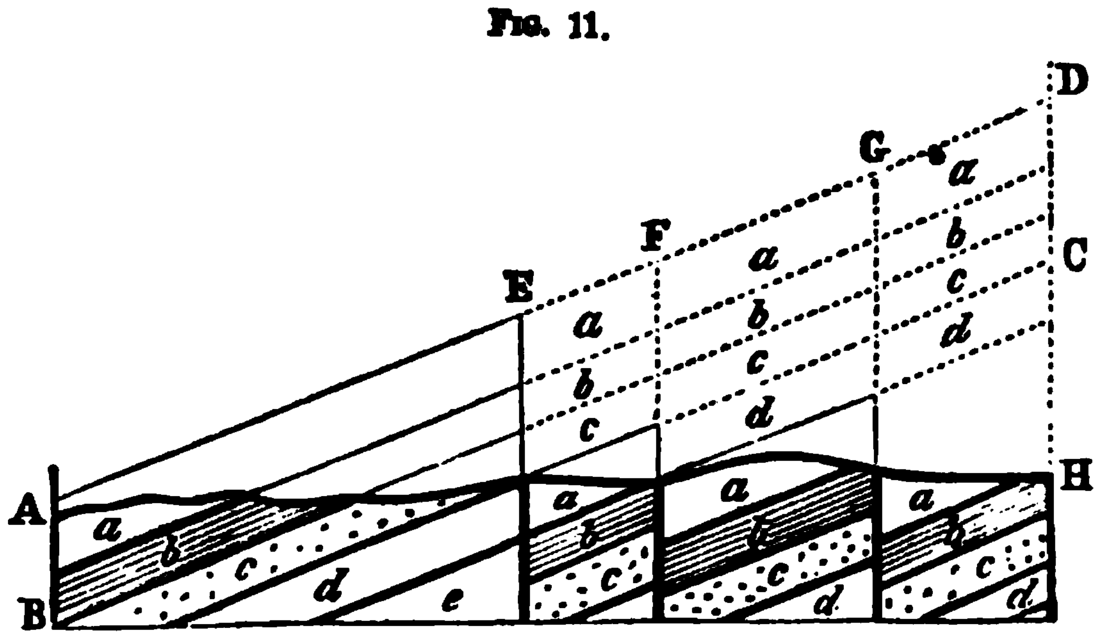
are very common in England, much more so than in America, and are called faults, and sometimes a mass of rock is found introduced between two of these fields, forming what the miners

Fig. 10.



call a dike. There are many very large coal-regions in this country where these faults and irregularities are altogether unknown.

Fig. 11.



The strata of rock in the coal-measures and the seams of coal, as a general rule, are parallel, and when they vary from

each other the lower seams of coal are more likely to be irregular and disturbed than the upper. A knowledge of the form of the neighboring strata of rock is therefore very important, as it determines that of the coal, and is more easily obtained than the latter. When a correct section of the rocks and seams of coal is once obtained, it may be relied upon as extending through the region, although the thickness of the strata may undergo changes.

How Coal-Seams lie in the Earth.

In England coal is usually found in nearly horizontal seams, but it is far underground, a large part of the island being covered by the newer rocks much later than the coal. Their shafts are 1,000 to 1,500 feet deep (the deepest colliery in England is 2,376 feet), and mining has been extended far under the sea. In the United States, east of the Missouri River, there is very little if any territory containing the coal-measures, with any later rocks than the Carboniferous over them. Our coal is generally near the surface, and, compared with other countries, it is surprising how little rock-cover we have over some very large coal-regions. There are many nearly horizontal seams of coal in America; those of bituminous coal are generally found in that position, affording great facilities for mining and drainage. These nearly horizontal seams, however, are generally parts of very wide and gently-curving basins, other parts of which perhaps have been removed by denudation. Sometimes the lower seams are broken up into numerous very small basins, with very steep inclinations and with an irregular thickness of coal, while the upper seams, like the Pittsburg, have an astonishing extent and regularity, so that an experienced surveyor and leveller can survey off the portion of the hill-tops which will contain the coal with sufficient accuracy to erect coal-works, almost without sinking a trial-pit to prove the level of the seam.

The Number and Size of Coal-Seams.

It is important to know the quantities in which coal is found, or, in other words, what are the number and thickness of the seams of coal, and what size is required for a workable

seam. To the unpractised, the finding of several beds of coal upon the same land appears to be a striking circumstance. Sometimes they are near each other, but usually they are separated by many feet and even hundreds of feet of rock. Here, Providence has not only blessed the earth, but has added blessing upon blessing, and, in these busy scenes of underground labor, we find a resemblance to the various stories of a large factory above-ground with its groups of workmen in their several apartments far above each other's heads. In the following chapters the number and size of the coal-beds in each region are given in detail.

There are no mountains of coal, except as a strong hyperbolical expression. There is a small mountain of iron-ore in Missouri; but the beds of coal, although quite regular and continuous, are very small compared with the other strata of the earth. Coal-seams are found as thin as a sheet of paper, and of all thicknesses up to the gigantic beds on the Lehigh Mountains, some of which are more than 50 feet in thickness. The bituminous coal-seams are usually from three to six feet in thickness in America, with exceptional instances of larger beds, such as that at Pittsburg, which is eight feet, and that at Cumberland, Maryland, which is 14 feet, and a 12-feet seam in Ohio; but generally all the coal in these large beds is not taken out to the full thickness. (But *see* p. 507.)

Workable Seams of Coal.

As to the minimum size of coal-seams that are workable, Mr. Smyth, in an English work on "Coal and Coal-Mining," says that he has measured a seam of coal that is worked in the Radstock district, in Somersetshire, England, as little as 11 inches. The late report of the Royal Commission included all coal-seams one foot in thickness. Seams of good coal 22 inches in thickness have been worked in Pennsylvania on a small scale. Such thin seams are worked, if at all, by taking out a part of the upper or lower rock with the coal so as to make more room. A seam of good coal three feet in thickness is well worth working, and miners call from two to three feet of clean coal in America, and from a foot and a half to two

feet in England, a workable seam. Small seams like these are also worked in Kansas. Of course, in the vicinity of larger beds of equally good coal, smaller ones are neglected, as the miners cannot compete in the market with those who work seams of considerably larger size with less labor and expense. The thickness of the coal is not in itself conclusive as to the quantity that can be produced in any given area. A three-feet seam will produce 4,840 tons to each acre of land, as each cubic yard of coal in the ground will produce a ton of coal; but the next question which arises is, How many of these 4,840 square yards in your acre can be successfully mined, and how much of your coal is marketable? In the Blossburg (Pennsylvania) region they have four and a half feet of coal in the Bloss seam, from which most of the coal produced is now mined, and it has an excellent hard roof and floor. After the rooms or breasts are all worked out, the pillars can be all drawn or taken out, and all the coal in the ground can be mined and taken away as clean as a farmer removes the hay from his meadow. The "run-of-mines" coal is sold to iron-works, and for locomotives and other steam-purposes; the larger or lump coal is used in glass-works, and for other special purposes; and all the fine coal is sold at an equally good price for blacksmithing. This is one of the best instances of the mining and useful application of the whole product of a coal-field, and, when the upper seam is exhausted, the same process can be applied to the lower seams on the same land.

On the other hand, in the Cumberland (Maryland) region the coal is 14 feet thick, but, for want of a good roof, or in some places from the supposed inferior quality of the upper and lower part of the coal-bed, only the middle part, from seven to nine feet in thickness of the very best coal, is mined. This, it is true, is a fine thickness of coal; but, unfortunately, the softness of the coal in this great bed, and the want of a strong, self-supporting roof, render it necessary to make the breasts or rooms only from 13 to 15 feet wide, and then a pillar is left in of 50 feet in width, as smaller pillars would crumble down, and these pillars cannot be successfully drawn, for fear of bringing on a fall of the roof, a *thrust*, or *crush*, as the miners call it. It will be seen that only a small proportion of the coal in each

acre can here be mined, and that the apparent disproportion between the great and the smaller seam of coal is less than at first appeared.

In the anthracite region the amount of minable coal is also small in those great beds, compared with the whole quantity in the ground, owing to the large pillars that must be left to support the mine. Three separate seams of six feet are better than one of 18 feet. Then, when we look at the loss attending the breaking of this hard coal, which is said to be fully 15 per cent., and often very much more, we will see that the proportion of marketable coal bears such a small proportion to the quantity which Nature had provided for us, as renders it any thing but a pleasant spectacle.

There are some sorts of bituminous coal, too, in which there is a great loss and waste on account of the market only demanding coarse, or lump coal. This is the case in the Pittsburg region, and in Ohio, where coal of a large size only is used, and a large portion of the slack or fine coal and nut-size is either abandoned in the mine or sold at a nominal price, barely sufficient to pay transportation. In America there is wastefulness enough above-ground, but it is not to be compared to that in mines.

Divisions in the Seams of Coal.

The thick beds of coal everywhere are seldom found to be of a uniform character or of clean coal throughout, but the various parts produce coal of somewhat different appearance and quality. A part may be more pure and free from sulphur or earthy matter, making less ashes than an upper or lower layer of the same seam, and many mines obtain or preserve their good reputation by the care taken in only mining or sending to market the purest and best part of the coal. Beds of coal are also frequently separated by interlying layers of slate of greater or less thickness, or by layers and balls of sulphuret of iron, which add greatly to the expense of mining, and require great care in picking out the pieces of these impurities which are broken in digging or blasting the coal. The carelessness of the slate-pickers, who are often small boys, fre-

quently entails upon the owners losses of money in the quality of the coal as well as of reputation. To a limited extent, therefore, coal, and especially anthracite, is a manufactured article.

Instead of slate, parts of the seam may be what is called "bony," which is caused by what was originally a muddy or earthy material, instead of forming a separate seam of slate, having become mixed and incorporated with the vegetable material of the coal itself in the process of its formation, producing a hard, dull-looking kind of coal, which is more difficult to separate from the good coal than the slate, and is equally worthless.

In bituminous and semi-bituminous coal, and in a less degree in anthracite, every seam is composed of an aggregation of small, well-marked horizontal layers, of perhaps about one-twelfth part of an inch in thickness or more. In addition to the main parting at the roof and floor, the coal-bed has generally other horizontal partings of the seam into different divisions. Then there is often another system of perpendicular partings, which are variously denominated "backs," or "dip-joints," and sometimes "slips." In the mines in the Blossburg region, these slips run south 13° east, and, as that suits the dip of the coal also, the gangways are run on that course, and such is their regularity, that the miners can keep their proper direction by them, so that the use of a compass is seldom required. In some kinds of coal there is a third kind of parting, at right angles to the last, called "strike-joints," or "cutters." When all of these occur, the coal can be mined out in cubical pieces, as is the case with the Pittsburg seam. When the system of joints is more perfect, the coal sometimes comes out like the "block-coal" of Youngstown, Ohio, and Sharpsville, Pennsylvania. When the subdivisions are more numerous, they cause the coal to break into smaller cubes, and thus injure its quality, but all of these fractures or divisions of the coal lessen the labor of the miner, and they are always in planes, except in the hardest anthracite, and in cannel-coal, where the fracture is conchoidal.

Uniform Quality.—Another peculiarity of coal-seams is, that the quality of a seam of coal is, as a general rule, the same throughout. J. P. Lesley compares it to a roll of broadcloth

in this respect, of which, if you unroll a yard or two, you have a fair sample of the quality and texture of the whole piece. There is, it is true, a selvage to it, but that you understand is not cloth. So the worn and exposed edges of a seam of coal are sometimes found mixed with the loose dirt or soil, and are not properly coal, but as soon as you clear that off and come to the coal itself, where it lies beyond the reach of the action of the frost, in its proper place between the rocks, well saturated with water, by getting a fair sample of it, you can determine its quality, which will be found to be very much the same as far as it extends. The miner may improve in the mechanical part of his business, slates may thin out, and the coal may be better prepared for market sometimes than at others, but, unless traced over quite an extensive region, the coal itself is generally the same to the end as it was in the beginning.

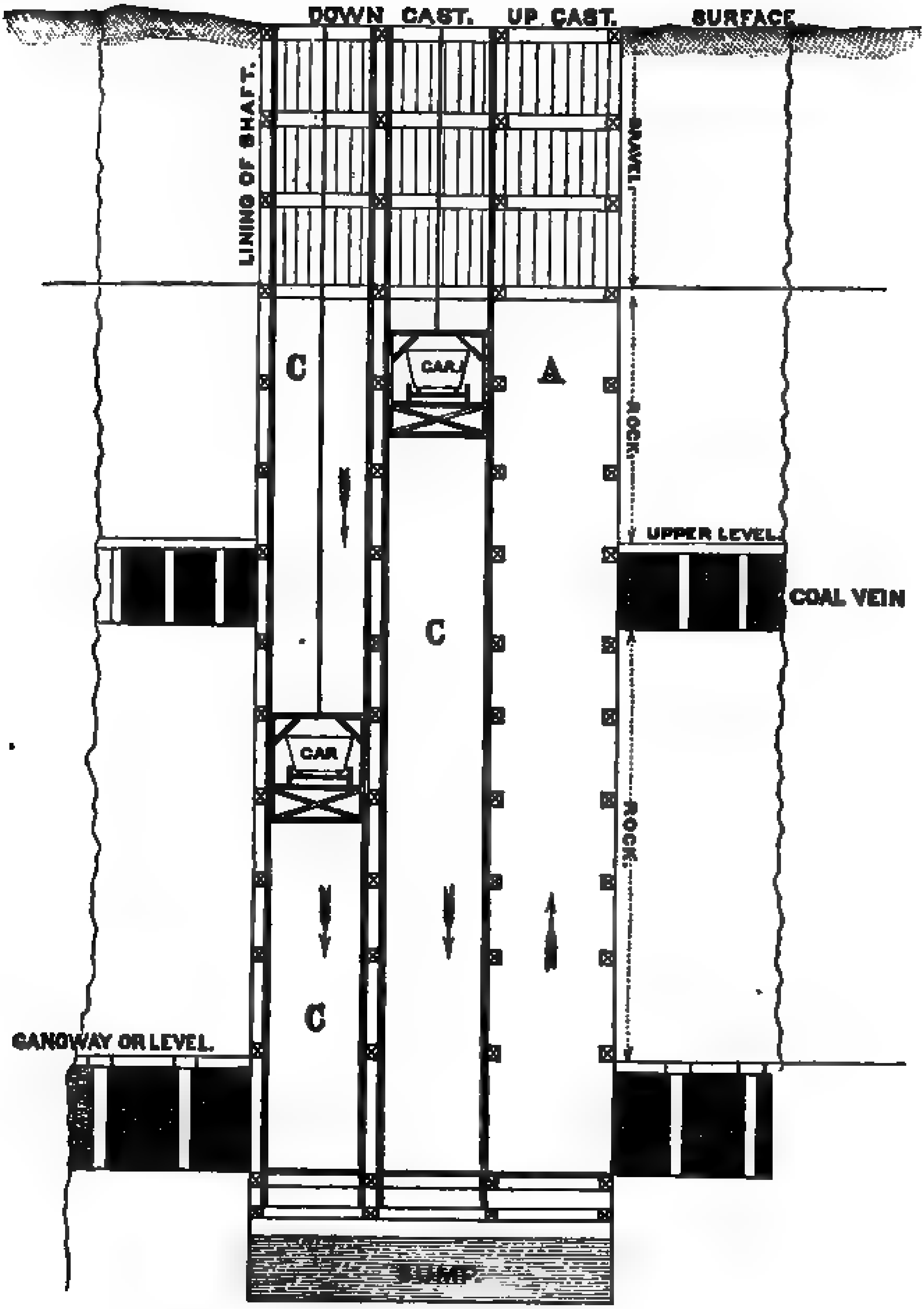
The purity of coal-seams, in the entire absence of particles of earth, sand, or other foreign materials, in the better varieties of coal, is very remarkable. Few productions of Nature are so free from foreign matter as coal, for we find it in the earth just as you use it. The miner of gold or silver must separate it from the earthy impurities and gross substances with which it is mechanically mixed, and, in the case of iron and other metals, not only must the ores be separated or cleansed, but they must be smelted, and undergo expensive and laborious operations, to separate them from those substances with which they are chemically combined, before they are fitted for use. But coal is found carefully deposited between smooth, clean, hard rocks, excluding all dirt, mud, or other injurious impurities. It is at once ready for the fire, and, if only separated from the surrounding impurities among which it is found, is certainly one of the most perfect works of the Great Hand which formed it. A production of the earth that is so useful it is manifest was intended for the use of man. As the perishable vegetation of our day disappears, or is removed for the cultivation of the soil, we find ourselves furnished with a better fuel, which has been safely laid away in rock-bound store-houses, in the most secure, compact, and imperishable form, for even the water which saturates it while in the earth preserves and improves its qualities.

Mining.—The edge of a coal-seam is not generally covered with rock, unless the coal has been casually removed, and the upper rock has dropped down and closed the opening. Usually the rocks and seam of coal are found broken square off together, and the edge is covered with loose soil, formed by the disintegration of the coal and the rocks above it; and the black powdery dirt of the coal, mixed with other soil, is sometimes the means of the discovery of the seam, but, more frequently in thin seams, the edge is covered by the ordinary soil nearly to the face of the seam, which here often shows its maximum dimensions. These edges, or out-crops, will appear on the side of a mountain, and many of the large eastern American coal-fields are found on the summits of broad, flat-topped mountains, forming elevated table-lands, with no very great height of rocks above the coal-seams. In these situations the dip of the coal is first ascertained, the mines opened on the lower side, so as to take advantage of the descent to bring out the coal on a railroad-track, and to drain the mines of water. If the country is not favored with mountains and valleys, as on the prairies of the Western States, access is had to the mines by sinking shafts or large wells to the necessary depth, and steam-power is used to elevate the coal and pump out the water. In China, where no such machinery is known, the water is carried out by an inclined shaft, the work being done by blind men, on account of their cheapness, one of these standing in each of the hollowed-out steps and bailing the water from his step to the one above him.

An elevator, as it is called in a factory, or in one of the large hotels or stores in our cities, will give a good idea of the machinery used in a coal-shaft, except that the latter is cut in the rock underground, instead of being erected in a building, and is divided into two parts, for ventilating purposes.

In our anthracite, and occasionally in bituminous, coal-regions, mining is done by slopes, which are simply inclined planes or sloping tunnels underground, generally cut in the coal-seam. After descending to a convenient depth, gangways are turned off to the right and left, in a nearly horizontal manner, and from these breasts, or rooms, are opened up the coal-seam. If the coal-seam is sufficiently inclined, as anthracite

FIG. 12.



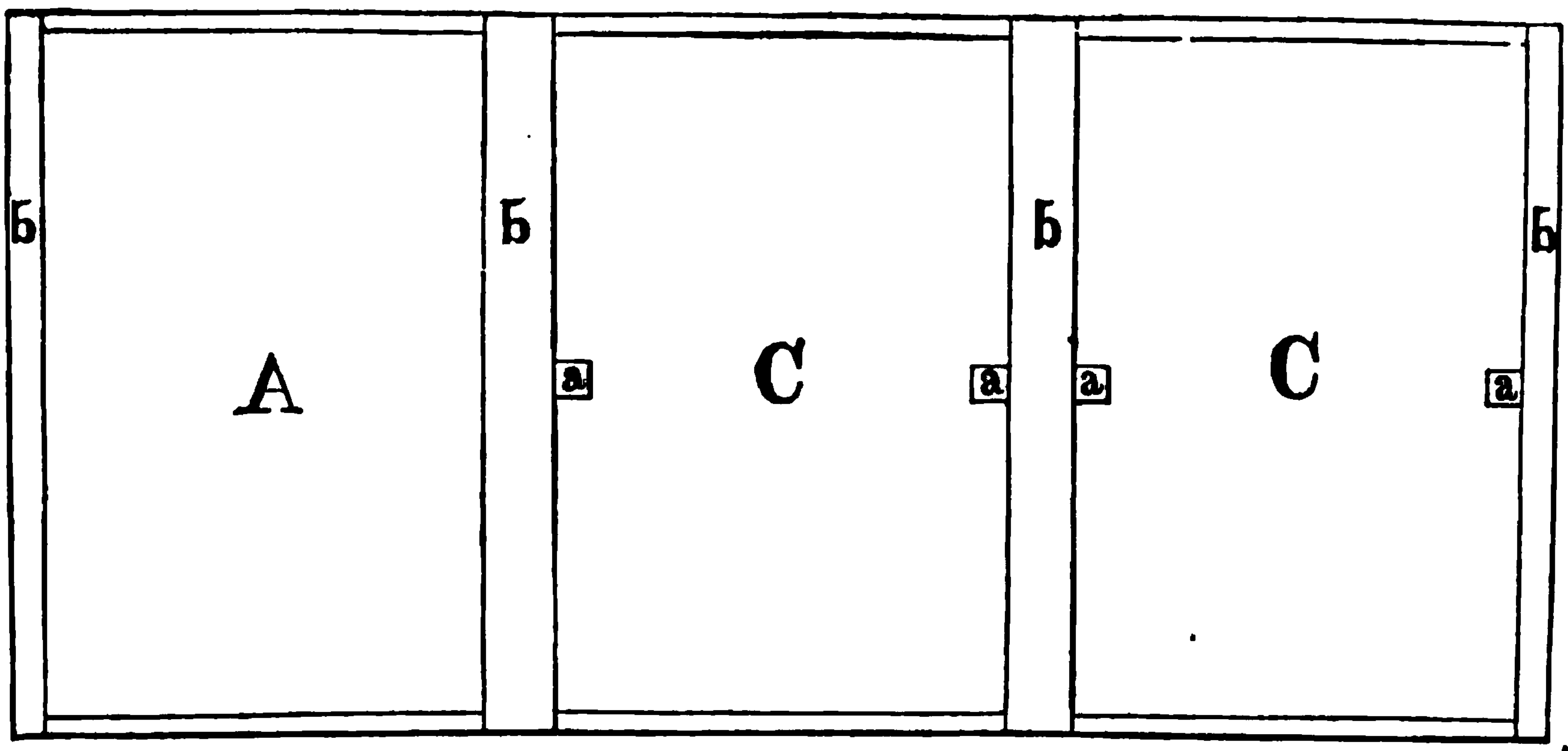
VERTICAL SECTION OF A SHAFT.

generally is, the coal is worked "on the run," as it is called, or by being allowed to fall by force of gravity down the smooth rock-floor of the chamber into the mine-cars.

The other, and, in the eastern bituminous coal-fields, the common, method of mining bituminous coal is by drifts, when the coal is above water-level, or can be drained, and the coal taken out without the use of machinery.

In opening a mine by a drift, the loose soil covering the

FIG. 13.



HORIZONTAL SECTION OF A SHAFT.

C, C. Carriage-ways in which the cars ascend and descend, also called Down-casts, as the air descends in them.
A. Air-way, called Up-cast, as the air ascends through it.
b. Cross-partitions, extending to the bottom.
a. Guides to keep cars in position.

edge of the seam is first removed, and a passage is made, lined with timber and plank as far in as the face of the coal, where it is found under a solid rock roof. (*See* Figs. 14 & 15.)

In examining the seam of coal which it is proposed to work, one of the most important items to consider is, whether it has a good roof, as the layers of rock immediately above the coal are termed. A hard, strong, self-sustaining roof is of the utmost importance in mining, and the safety and economy with which the mine may be worked depend very much on this. Your black diamonds, to be valuable, must be in a rock-bound casket, and the roof should be impervious to water; therefore, see that you have rock as well as coal, for sometimes an apparently good

outcrop of coal is found with but little covering of rock over it, or with so shaly and crumbling a roof that the coal cannot be profitably mined. There may be a sufficient depth of covering over the coal to warrant you to expect good coal, but the strata immediately over the coal may be fragile clay-slate, or shale, the former being such as breaks into thin and even plates like roofing-slate, and the latter being also fragile, and breaking into plates, but more unevenly. In such cases, the expense of timber supports may be ruinous, or, in working a seam of this kind, an important part of the top of the seam of coal must be left unmined, to strengthen the roof, and the production of coal per acre is thereby very much lessened. The shale or slate over coal, however, is often very hard and strong, and then it makes a good roof. Frequently the sandstones, or, in the Western States, limestones, are in immediate contact with the coal over-

Fig. 14. Fig. 15.

head throughout the coal-field; or, in a part of it, the roof may be sandstone or limestone, and, in other parts, slate or shale. A regularly-bedded limestone or sandstone is the strongest roof, and admits of making wider chambers in the mines, requiring fewer props and less timbering. Sometimes the coal adheres very closely to the roof, which demands more labor in mining than where there is a good parting and the coal separates readily from the roof-rock.

The depth of cover, or rock, over the seam of coal to the surface of the ground, necessary to form good and minable coal, varies, in different localities, from ten to thirty feet, or more, and varies, also, with different kinds of coal. In this, as in many other particulars, it is best to be governed by the experience of other mining-operations in the region.

The floor, or bottom, of a coal-seam is almost always fire-

clay, and, if it prove to be soft, it is as unfortunate as a bad roof, as the wooden props, used in supporting the mining-chambers, and even the pillars of coal left in mining, will be forced into

FIG. 18.

Main Coal, 6 feet 6 in.

Metal Coal, 3 feet.

SECTION OF CARBONIFEROUS STRATA, AT WALLSEND, NEWCASTLE, SHOWING "CREEPS." (J. BUDDLE, ESQ.)
Horizontal length of section, 174 feet. The upper seam, or main coal, here worked out, was 630 feet below the surface.

the clay by the weight upon them, and the bottom-clay, when wet, rises up and fills the mines, which is called a creep. Fortu-

nately, this is not of very frequent occurrence; it is sometimes seen in Illinois, but, generally, the fire-clay has indurated into shale or hard rock. This fire-clay is sometimes several feet thick; it is often quite pure, and is then valuable for the manufacture of fire-brick; and in it are often found the fossilized roots and stumps of carboniferous trees, showing that it was

FIG. 17.

Fossil Tree at Right Angles to the Planes of Stratification.—Coal-Measures, Nova Scotia.

the subsoil of the vegetation of which the coal was formed. On the coasts of Nova Scotia may be seen eighty-one different small seams of coal, in more than twenty of which stumps of trees are seen standing erect with their roots in the fire-clay, and their trunks at right angles to the original plane of stratification,

FIG. 18.

Erect Fossil Trees.—Coal-Measures, Nova Scotia.

and their tops apparently rotted off at the surface of the ancient water or bog. In the sandstone which fills their interior are sometimes found fern-leaves, which had evidently

entered with the sediment after the stumps had decayed and become hollow, and while they were still standing under water.

It is surprising to observe how many fortunate contingencies must combine in a coal-seam to furnish a valuable body of coal. To this must be added a far larger number of circumstances to make a prosperous business, as will be noticed in the chapter on the conditions of success in the coal-trade. But, while few coal-seams are perfect in all respects, there are scarcely any of the difficulties mentioned which cannot be overcome by the application of the necessary skill, labor, and expense.

From what has already been said, such readers as know nothing whatsoever about mines will have learned that coal is not found in masses extending to the surface and excavated like building-stone from great open quarries. Such instances as that at the open mine at Summit Hill are very rare indeed, and could only exist to a limited extent in the infancy of the mining-business. As this account is written for all, it may be well here briefly to describe the plan of a coal-mine of the most simple kind in a nearly horizontal seam. First, a narrow tunnel is mined out in the coal-seam, only wide enough for a railroad-track, for a large or a very small car, according to the thickness of the seam of coal. In thin seams, these railroads are very diminutive. From the main gangway, branch-roads are made to the right and left, and from these are opened wide chambers, as large as the strength of the roof-rock and the hardness of the coal will allow, and in these the roof is usually temporarily supported by wooden props, as well as by pillars, or portions of the unmined coal left in proper position for the purpose of support between the chambers and between them and the roads or gangways. Thus our coal is mined out underground, each miner working by the light of a lamp, and constantly making his workshop larger and larger, with a solid rock-roof over his head, a rock-floor beneath his feet, and the side-walls of black, unmined coal. (*See* plate on page 145.)

The mining of anthracite coal is done chiefly by blasting. The work of mining bituminous coal is done by cutting beneath the coal-seam as far as the miner can reach with a very sharp-pointed slender pick, and also along the side of the chamber.

Then, by driving in wedges horizontally along the top, the mass of coal is thrown down. Powder is occasionally used in small charges, instead of wedges, but the use of it is objectionable, on account of the coal being thus broken too fine and causing too much waste where it is desirable to have lump or coarse coal. The manner of working coal, however, depends upon the size and peculiar character of the bed, and is therefore very different in the various regions and even in different mines in the same region, but it is work which requires skill and practice, particularly in the mining of bituminous coal.

In opening a mine a single gangway is first driven in the coal-seam, *a c*,[1] but it is very soon found that mining to any extent cannot be done in this way, as, after going in a short distance, say about 100 yards, the air becomes impure, so that a man cannot labor, and even life cannot be sustained. To obviate this difficulty, a second gangway, *b d*, must be made parallel to the first, with a cross-passage, *a b*, communicating from one to the other at the farther end. When this is done, fresh air will come in at one opening, cross over and pass out at the other. This second gangway is called the air-course, but it is made to begin from a shaft, U, over which a chimney is erected, and, when necessary, a fire is kept burning at the bottom of the shaft. The draught thus produced[2] carries up the air, and thus fresh air is forced to pass into the main gangway or entrance of the mines, D, or the down-cast in the shaft, and in succession through all the passages and chambers in the mines, by preventing communication between them except in one direction. As the gangway and air-passages are extended, new openings, *c d*, communicating from them to the other parts of the mine, are opened, and the old ones, *a b*, closed.

A very interesting point in regard to the ventilation of mines is the dividing, or, as the miners call it, *splitting the air*. When mines became extensive, the forcing all the air in one current through all parts of the mines was attended with inconvenience and difficulty; the progress was slow, and all the impurities of the whole mine were carried through every part of it. It is found, however, that if a current of air is allowed to select between two passages, both communicating with the

[1] Fig. 19. [2] Fig. 20.

upcast or ventilating chimney, it will not all take the shortest, but will divide itself, a portion going through one set of headings or breasts, and the remainder through the other set.

FIG. 19.

FIG. 20.

Each separate split of air should commence as near as possible to the mouth of the drift or downcast shaft, and be brought out as near the upcast shaft as possible. The form of the air-courses

should be such as to afford the largest area to the smallest perimeter. The friction of the air against the walls is the greatest obstacle to ventilation, and this increases as the squares of the velocity. The advantage of splitting the air is, that the quantity of air carried is greater than with a single gangway, because the movement is slower, the friction of the moving column of air on the walls is therefore much less, and much more air is moved in the same time by the same draught-power. Nothing is so expensive as speed, and nothing so cheap as a slow movement.

"Holing Coal."—The collier, lying on his side, with his neck bent in a most painful position, makes an horizontal cut with his pick at the bottom of the seam.

"Putters, or Trolley Boys," in England, formerly.

VII.

THE FIRST OR ALLEGHANY COAL-FIELD.

THE most important feature of the North-American Continent in connection with our subject is the Alleghany Mountain, which is called the Cumberland Mountain in the South, and which contains, or rather is the eastern boundary of, the largest and in all respects the most important of the American coal-regions. The whole length of this mountain is about 1,300 miles, but the portion containing coal, extending from the northern part of Pennsylvania to near the central part of Alabama, is about 875 miles in length; and the more northern part, containing no coal, may be left out of view. The most remarkable peculiarity about this mountain is the great regularity of outline of the east or rather southeast summit of the ridges. It is not of an unusual height, and does not vary much in altitude, being usually about 1,000 feet above the adjoining valley and about 2,000 feet above the sea, but it pursues a remarkably straight course, sometimes hardly diverging from a direct line for a distance of 50 or 60 miles. Throughout its entire length it pursues a uniformly northeast course, and from the North Branch of the Susquehanna in Pennsylvania to the line between Tennessee and Alabama, where its southern extremity is severed by the Tennessee River, it is one continuous, unbroken range of high table-land, except where it is in a great measure divided in West Virginia by the Kanawha River and its branch the New River, and throughout this whole length there is no clean cut through the range. The highest geological formations are the coal-measures, which dip westwardly at a steeper angle than the inclination of the mountain, and

bring in other and higher beds as the distance from the mountain increases. In Southern Pennsylvania several other ridges occur west of the Alleghany Mountain, called Negro Mountain, Laurel Hill, and Chestnut Ridge, about 10 miles apart, and each about 10 miles wide at the base crowned by conglomerate rocks.—(J. T. Hodge, in "American Cyclopædia.")

This great Alleghany coal-region of Western Pennsylvania and Virginia narrows down through Tennessee, and tapers in several parallel fingers into Georgia and Alabama. Its eastern edge is well defined from the North Branch of the Susquehanna in Northern Pennsylvania down to Chattanooga, everywhere overlooking, from the crest, along that immense line, the deep older secondary valleys between it and the great concentric curve of the Highlands in New York, South Mountain in Pennsylvania, Blue Ridge in Virginia, and Smoky Mountain farther south. Its western edge is everywhere more uncertain and meandering from its gentle dips, irregular denudation, and thinning out of those immense deposits of sandstone and conglomerate which fringe its eastern edge with parallel subordinate mountains. This great coal-region may be said to have no spurs on its eastern, but innumerable spurs on its western margin. Toward the northeast, the rising of its sub-basins in that direction brings it to an end along the line of New York State in six long, slender parallel fingers, on the top of which the last remnants of the lowest seams of coal linger, and are mined at Blossburg, Towanda, Ralston, and the Mahoopeny in Pennsylvania. Such is also necessarily its manner of terminating southward in Georgia and Alabama, in the three or four long mountain-prongs the Lookout, Raccoon, and Huntsville Mountains, which all retain upon their summits fragmentary patches of the coal, including the one, two, or three lower beds. —(J. P. Lesley.)

Although it will be necessary to describe the coal-regions as they are divided by State lines, yet it is important, in the first place, to get a correct general idea of this, the first or eastern coal-field as a whole. "This great coal-field," says Rogers, "almost the largest expanse of continuous coal-measures in the world, possesses a length of 875 miles, and a maximum breadth between its eastern outcrop in Southern Pennsylvania, and its

western in Northern Ohio, of about 180 miles, while it covers about 56,000 square miles of the earth's surface."[1] It extends, as has already been said, from Northern Pennsylvania to Middle Alabama, parallel with the Appalachian mountain-chains east of it, many of whose ridges rise within its borders and insulate valleys of the coal-bearing strata.

A good general idea of its structure can be obtained by a careful study of the rivers by which it is drained, assisted by brief descriptions of its formation. The geological counterpart of the Alleghany Mountain on the east, is found on the west side of this great coal-basin in the anticlinal axis passing through the west end of Lake Erie, where it forms several islands, and which extends thence in a southwestern direction past Cincinnati, and thence through the central part of Kentucky and Tennessee. For, although there is no mountain now appearing on the surface, it being a low and broad axis of elevation, there has evidently been a vast upheaval of the lower rocks; so that, if we can imagine the irregularly-disposed upper deposits of drift and soil removed, or the denuded formations restored, we would see this as the western rim of this great basin from which all the rocks of Eastern Ohio dip eastward, just as from the eastern brow of the Alleghany Mountain they dip westward and those of Northern Pennsylvania southward. The outer borders of this vast basin in Ohio, from Cincinnati to the Scioto River, contain no coal, which is confined to the interior space or eastern part of that State, where the strong foundation of conglomerate rock has preserved it for our use. On the western border, in Ohio, the Scioto River is seen borne off southward by the outcrop of the conglomerate, while the drainage of the conglomerate upper surface is eastward into the bosom of the basin. On the northern boundary, in Pennsylvania, of what is left of the coal-basins, the West Branch of the Susquehanna cuts through and across the northern finger points.

Along the uniform eastern, or rather northeast and south-

[1] The following are the areas of the portions in each State, viz.: Pennsylvania, 12,774; Maryland, 550; Ohio, 10,000; West Virginia, 16,000; Eastern Kentucky, 8,983; Tennessee, 5,100; and Alabama, 5,330, or in all 58,737 square miles. Those of Pennsylvania and Eastern Kentucky are the result of surveys and careful calculation; the others are estimates, and probably some of them are not very accurate.

west boundary of the Alleghany Mountain, hundreds of miles long, no streams of any magnitude flow out of it eastward, its straight, sharp edge forming the most uniform divide or watershed on the continent. As we follow it farther south, we see the Tennessee River following along its eastern outcrop, seeking in vain for a passage westward, from Virginia to Alabama, until it finds it at the great rift through the narrow neck of this vast coal-field at Chattanooga just as the North and West Branches of the Susquehanna cut across its narrow northern extremities. But the rivers and streams in the interior of this area show in a most striking manner its basin-like form as far south as West Virginia, and its general structure. The Alleghany River drains it from near the south border of New York down over the south-dipping strata through the northern central part of the basin. The Beaver River and other smaller streams perform the same office a little farther west, while, as before noticed, in Ohio, the Muskingum River and other shorter, smaller streams within the coal-basin emptying into the Ohio, indicate the dip of the rocks in that quarter. But the strangest of all is the anomalous course of the Monongahela River, almost the only one in the United States which flows northward, not belonging either to the system of rivers which flow into the Atlantic nor apparently to those which flow into the Mississippi, but simply the water-way for the interior of this great coal-basin, running northward to the Ohio with but little fall, and keeping in the same geological level in the Barren Measures midway between the upper and lower systems of coal-seams. Its neighbor, the Youghiogheny, emptying into it from the southeast, indicates the same basin-like formation.

Then, finally, the Ohio makes a *détour* northwestward around the upper coal-measures and runs down the middle of the great coal-field against the shales of the Barren Measures, as far as Burlington, at the Kentucky line, and then turns and breaks across the lower rocks toward Cincinnati. South of the Ohio, on the west side of the basin, the Kanawha cuts another course through the rim of the basin, making a large amount of the coal-seams more accessible, and its valley with its branch the New River, as before noticed, being the only water-

course through the coal-measures from east to west in the whole length of the field. The Big Sandy and the head-waters of the Cumberland are thrown off westward; and, finally, the southern detached Alabama coal-field, dipping southward, shows the structure and inclination of the strata by the course of the Big Warrior and its branches, with a fall of 1,000 feet down to Tuscaloosa. There is no sheet of water within the boundaries of this great coal-field deserving the name of a lake. Further details on this subject will be given in considering the several regions separately. The reader is particularly referred to Prof. W. B. Rogers's fine description of the general plan and structure of this vast coal-formation, which will be found under the heading of "West Virginia."

In looking over this very extensive region of country, which is so richly supplied with mineral coal of every variety, and observing the great number and fine size of the seams, many readers will be liable to over-estimate the real present value in a commercial sense of the land which contains it and the accessibility of its mineral treasures. Let us, therefore, make some corrections.

It is easy to define on a map the varieties of the surface, such as mountains, valleys, and prairies, or even the nature of the soil and surface-rocks, or the geological formations, but, until the treasures beneath the surface have been developed by mining or searching for them, all that a geological map can show as to the coal-fields is, to define the limits of the system of surface-rocks in which experience has proved that coal may be expected to be found. This system of rocks, called the Carboniferous, is generally several hundred feet in thickness, and embraces not only the beds of coal and the rocks immediately over them, but also those upon which the coal is placed which forms the foundation or floor of the coal-formation. These lower rocks belong scientifically to the Carboniferous formation, because they contain fossils of coal-plants. Occasionally small seams of coal are found in them. Sometimes these formations are of very great thickness, covering a wide area outside of the coal-seams, and therefore form a proper subject for deduction when we come to scrutinize the area of actual coal-producing territory.

In many places, too, the coal is found only on the highest ground, perhaps on the summits of the hills or mountains, the valleys being destitute of coal. But the small scale on which maps are drawn does not permit the proper representation to the eye of these barren, intermediate spaces, or, from the want of full and correct geological surveys, we have no proper data for the corrections. In some localities there may be one large or upper seam of coal which, either from its size, or the superior quality of its coal, is, in the present state of the coal-market, the only one that is available or valuable, and which may cover a comparatively limited area, while there are other lower, smaller, less valuable seams, or of inferior quality, but extending over a far greater extent of territory, or perhaps buried at an inaccessible depth, and which are scarcely ever mentioned or thought of by the land-owner. A good example of this is the great Pittsburg seam, and the Barren Measures, more than 300 feet in thickness, which are immediately beneath it. The latter has a wide extent, covering often very large areas to a great depth where the topography is such as to postpone for a long time the probability of the deeply-buried lower coal-measures being mined.

Add to all this the want of railroads, or navigable streams, or other avenues to market, the large amount of capital required to make such improvements, to open mines, and carry on mining operations, the many contingencies and risks attending the coal business, which are given more in detail in a subsequent chapter on the coal-trade, and the want of demand for the fuel within a proper distance, for, after all, coal is only valuable where there is a consumer.

These are some of the reasons which should lessen the envy which those who have no coal might feel toward some of the possessors of these coal-regions. In some respects, coal in the ground, like a good soil on the surface, is not valuable in itself or alone, but is only a place where that which is useful to man can be produced by the expenditure of labor. Still, with all the corrections that may be made, this great Alleghany coal-field is one of remarkable and even of wonderful extent, almost the largest and most valuable in the world, and, considering the anthracite regions as a part of it, it produces every possible

variety of the best qualities of fuel. "No political economist now would dare to estimate the present or future riches of a people and their resources without taking for a basis of his calculations the facilities for procuring a supply of coal. The most celebrated geographers and philosophers of our time have asserted that the Continent of North America, and especially the valley of the Mississippi, would at a future day become inhabited by the densest and most civilized population of the world, because it has in its extensive coal-fields the largest amount of coal, that originator of industrial life."—(Lesquereux.)

Another very interesting subject in connection with this great coal-field is, the distribution of the several kinds of coal produced in its various parts.

Northwestern Gradation of the Coal.

The variety in the kinds of coal found in different localities, suggests the inquiries as to whether it is fortuitous, or whether there is any general law by which it is governed; what is the law, and how is the effect produced? In a universe governed by law there must be some system to the coal-formations.

One of the most obvious phenomena in regard to our Pennsylvania anthracite coal-fields is, that the hardest coal is found in the east ends of the first and second coal-basins, contrasting very strongly with the soft, free-burning, semi-anthracite of their west ends. The line of gradation in softness might, at first glance, appear to be from east to west, perhaps on account of these two fields lying nearly in that direction. But a little observation will show us that, in fact, the course of this progression is from the southeast toward the northwest. A line, crossing this course at right angles, and thus corresponding nearly with the general course of the Atlantic coast, would represent the crest, as it were, of the wave of change.—Upon a geological map, the southeast-northwest course would first strike the stony anthracite fields of Rhode Island and Massachusetts, in which, under a high temperature and intense pressure, all volatile matter has been expelled, and all vegetable impressions obliterated.

The next coal-field, as we move the line northwestward, is the Old Lehigh Navigation Company's mines near Mauch

Chunk, then the Hazelton Beaver Meadow, and other Lehigh basins, before referred to, producing the hardest anthracite, which is of peculiar value for foundery purposes, in melting pig-iron. A little farther northwestward comes the Pottsville coal, of a medium hardness; and here also, by this rule, we are in the line of the Great Northern, or Wyoming and Lackawanna coal-field. This third coal-field lies in nearly a northeast and southwest course, and, according to the theory proposed, it should produce throughout its entire length from the same seams, a nearly uniform quality of coal as regards its hardness. This is found to be the case. If there be any observable difference, that produced by the Delaware & Hudson Canal Company, in the north horn of this crescent-shaped field, should be a little the hardest, and that from Nanticoke and Shickshinny the softest. That produced in the central part of the field at Scranton and Wilkesbarre should, in obedience to this theory, be of the same general character as that from the same seams of the Mahanoy and of the widest portion of the Schuylkill basins. As we move our line farther northwestward, it first passes the extremity of the southern fork of the first coal-field, then that of the north fork, while the line has not much passed Shamokin in the second field, leaving the Trevorton end of that field the softest of all the anthracite coal in the three regions—as it is known to be. It is thus described in the State Geological Report: "Passing the meridian of the Shamokin Gap, the coal acquires a sensible quantity of inflammable gas, carburetted hydrogen, characteristic of the bituminous and semi-bituminous class of coals, and the proportion of this ingredient seems rapidly to increase as we draw near to the extremity of the basin.[1] It seems to exist in the coal in the gaseous form, or, if a portion is in a condition of liquid bitumen, it is in quantity too minute to cause the coal to soften and form coke. The coal is therefore to be regarded as an anthracite, but of modified properties."

It might have been noticed, in passing, that the character of the coal produced in the two prongs at the west end of the Schuylkill basins forms no exception to the supposed rule, being a little harder than the Shamokin, and softer than the Pottsville.

[1] Mr Daddow thinks there is no gradation, but a sudden change in the anthracite.

Passing northwest over an intermediate space in which no coal is found, we next meet with the detached semi-anthracite coal-field on Birch Creek, Sullivan County, Pennsylvania, which possesses the character which its situation requires, having the fracture and general appearance of semi-bituminous coal, but burning in all respects like anthracite of a soft, free-burning variety, being even softer than the Shamokin.

The semi-bituminous coal-field of Blossburg and Barclay, in Northern Pennsylvania, the next in order, and that of Broad Top, in the southern part of the State, and the Cumberland coal-region in Western Maryland, as well as the intermediate basins of Snowshoe and Phillipsburg, Pennsylvania, all produce coal of the same general description, and all lie in the same northeast and southwest course. This zone of coal is of a transition kind, and the changes seen in all coal elsewhere, southeast or northwest of this line, seem to show that this is the only part of the country in which this peculiar quality of dry semi-bituminous coal, making a good, hollow fire for the blacksmith, may be expected to be found; but it might be looked for anywhere on the east side of the Alleghany coal-field southwest from Cumberland, Maryland, even down to Chattanooga or Tuscaloosa, Alabama, although the southern extension may represent a more central part of that great field. The Tennessee coal, by its analysis, must be semi-bituminous.

The insulated character of the Pennsylvania semi-bituminous fields does not permit us to fix their original width, but this coal seems to extend into the southeastern edge of the main body of the Alleghany field, and becomes more bituminous toward Johnstown.

Prof. H. D. Rogers ascertained by analysis in 1837 that the quantity of volatile matter in the coal of the great Alleghany coal-field increased in a northwestern direction from 16 per cent. in the southeast to 50 per cent. on the Ohio River. He further reports that this progression is observable in the same bed, as, for example, the Pittsburg seam, which contains 15 per cent. on the Potomac, in the Cumberland basin, 31 per cent. at Blairsville, and 43 per cent. at Pittsburg and on the Kanawha. The Brier Hill coal, in Ohio, which has since been developed, contains as much as 40 per cent.

In the northwestern part of the Alleghany coal-region near the State line at Youngstown, Ohio, and about Sharpsburg, on the Pennsylvania side, is found this peculiar and very valuable laminated splint coal, known in the region as "block-coal," highly esteemed for smelting iron in the Mahoning Valley. It also commands a large market at and from the ports of Erie and Cleveland, as a grate and steam coal in the West. The Big Muddy coal mined at Carbondale, Illinois, and brought out to Grand Tower, on the Mississippi River, below St. Louis, and that of Chester, are of a quality somewhat similar to the celebrated Ormsby and Brier Hill coal above described, and lie nearly in a southwestern direction from the Youngstown and Sharpsburg region.

A good quality of coal occurs at Brazil, in Clay County, Indiana, between Terre Haute and Indianapolis, on the east edge of the Illinois coal-field, which has been successfully used in blast-furnaces. This is the much-talked-of block-coal of Indiana.

The Nova Scotia and New Brunswick coal-regions are in the same coal parallel with some parts of the Alleghany regions, producing bituminous coal of the same quality. The supposed meridian line, when traced for long distances, like all Nature's lines, probably assumes a curving form, conformable to the great flexures of the continent.

But, as we extend our observations farther to the northwest into the other coal-fields, we meet with other important changes in the character of the coal, the most noticeable of which, as affecting its economic value, is the presence of a largely-increased quantity of water and sulphur. The coal of the Alleghany coal-field is so uniformly dry that the quantity of water it contains is scarcely ever noticed in the tables of analysis. For all the useful purposes to which coal can be applied, that produced in the great Alleghany coal-field, extending from Towanda and Blossburg in Northern Pennsylvania to Tuscaloosa, Alabama, and from Mauch Chunk, Pennsylvania, in the east, to Massillon, Ohio, in the west, is very far superior to any other coal on this continent.[1] The coals of the Illinois and Missouri regions are highly charged with water, those of northern Illinois containing as high as 12 per cent.; hence, and because

[1] Except the Indiana and Nova Scotia coals.

they are so sulphurous, they disintegrate rapidly on exposure to the atmosphere.

Moving our parallel farther northwestward, we come to a zone of inferior coal, mined at Jackson, Michigan, and at Belleville, Illinois, St. Louis being supplied from the latter. Also, farther northwest, we have that produced along the northern part of the Illinois coal-field, at Wilmington and La Salle; and southwest from them is Bevier, in Missouri, five miles west of Macon, on the Hannibal & St. Joseph Railroad. They are equally sulphurous, and contain so large a percentage of hygrometric moisture as to fix them in the same class beyond question. But as yet there appears to be but little evidence of any gradation in the Illinois, Iowa, and Missouri coal-fields. They appear to have been beyond the influence of the metamorphosing agencies which improved the coal farther toward the east. But there is evidence of their effect in Arkansas, where a semi-anthracite or semi-bituminous coal is produced.

Heat was, no doubt, the agency referred to. There is no evidence of volcanic action in the coal-regions, nor was it required. The correlation of forces is now generally understood, heat being the result of force or motion. In this case it was developed by the plicating of the strata for at least seven miles in depth, just as the temperature in a mine is greatly increased by what is called a creep (*see* p. 96).[1] The metamorphism of the coal-beds is measured approximately by the degree of disturbance of the strata in the district. It was greatest toward the ocean, being in excess in Rhode Island; and its work was well done to serve the purposes of man at Mauch Chunk and Pottsville, at Blossburg and Cumberland, at Pittsburg and Youngstown. But the Appalachian revolution was confined to the Appalachian or Alleghany coal-field, and did not cross the older Silurian axis at Cincinnati. The Mississippi Valley has its endless prairies, unbroken by mountains and valleys at the expense of the good quality of its coal, for it appears Nature could not give both together.

[1] In one instance, in Wales, the heat produced by this cause was so great, that it was feared it would set fire to the coal.

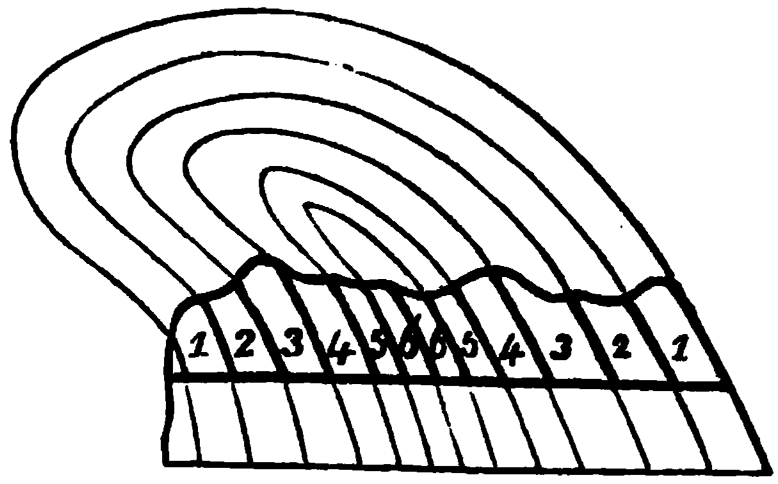
VIII.

PENNSYLVANIA BITUMINOUS REGIONS.

PENNSYLVANIA has, within her borders, not only all the valuable anthracite coal of America, but she possesses the finest field of bituminous coal, not surpassed by any for the beauty of its structure, and affording every variety of that description of coal of the best qualities, and in a very accessible form. To avoid misapprehension as to the situation of this coal-region, a glance at the eastern part of the State outside of the bituminous coal-region is first necessary. The southeast angle of the State, from Philadelphia northwestward to Harrisburg and Reading, may be considered as a fertile, undulating plain, rising gradually to an elevation of from 150 to 300 feet, composed of both the oldest and the newest rocks of the State. This plain of the Atlantic slope is bounded on the northwest by the South Mountain, which runs from Easton to Reading, and then with a long interval begins again west of the Susquehanna between Cumberland and York Counties, and runs through Adams County into Maryland and Virginia under the name of the Blue Ridge. This ridge is, in Pennsylvania, a stony, narrow mountain, only 400 to 500 feet high above the adjoining valleys, and composed of primary rocks and Potsdam sandstone, the lowest in geological position of fossiliferous rocks. Proceeding northwestward, crossing the Cumberland Valley, which is from 10 to 18 miles wide, composed of Trenton limestone and Hudson River slate, the next two formations in geological order, we now come to a series of ridges and narrow valleys, the first of which is the Blue Ridge, called by the Indians the Kittatinny, or Endless Mountain, being a continu-

ous mountain which nowhere subsides, but only here and there shifts its crest-line by a jog or set-off, and has no interruption except at the five river-passes or water-gaps, by which the rivers Delaware, Lehigh, Schuylkill, Swatara, and Susquehanna, flow through it. With these exceptions it is one continuous mountain, about 500 feet high, from Rondout, on the Hudson, southwestward through New York, New Jersey, and Pennsylvania, to Franklin County, on the borders of Maryland, a distance of about 240 miles. It is composed of Oneida conglomerate, with Medina sandstone on its western slope, or forming its second ridge. Going on northwestward this mountain is succeeded by a complex chain of long, narrow, very level sandstone mountain-ridges, separated by long, narrow, parallel shale and limestone valleys, which are the result of an elevation of the strata or earth's crust in long, slender, parallel waves, and of the wearing away of those waves by water. This is a region more than 50 miles wide, embracing the counties of Bedford and Fulton on the south line of the State, and extending northeastwardly across Pennsylvania to Wayne and

FIG. 2'.



Pike Counties, and composed of the other geological formations below the coal, but including the anthracite coal-regions. This remarkable district shows a degree of disturbance caused by upheavals in a wave-like form, and a bending or forcing of these vast waves together apparently by a force, applied from the southeast, which is truly wonderful, the waves being often thrown over past the perpendicular, and then the broken and exposed edges of the strata worn and washed off or denuded in a manner and to an extent which nothing that we now see in Nature would enable us to understand.

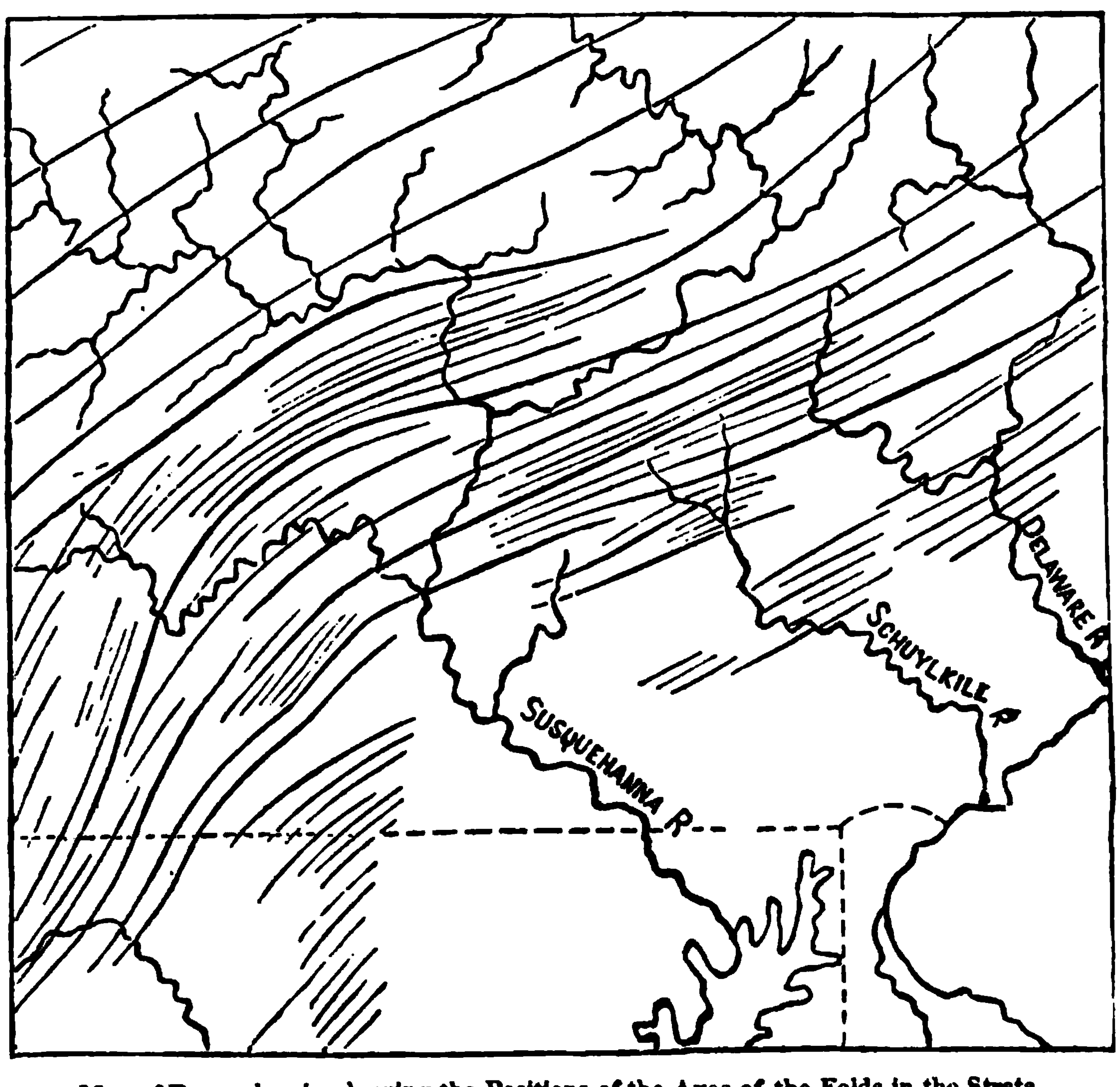
The effects of these disturbing forces are visible to a less extent throughout the great bituminous coal-region west of the district described, and it is mainly on this account that this reference to them has been made. Nearly the whole of this wide mountainous zone of the State embraced between the Cumberland Valley and the principal ridge of the Alleghany Mountain should be called the Appalachian region This term has sometimes been applied to the whole of the great bituminous coal-bearing table-land which traverses the United States from New York to Alabama, but, for the sake of greater exactness, the latter region should be designated as the Alleghany. The two systems of mountains are entirely different, both in their appearance and geological structure.

Pennsylvania and New York Geological Nomenclatures in the Ascending Order.

Pa. Nos.	H. D. Rogers's Nomenclature, Pa.	New York Nomenclature.	
	Gneiss	Huronian, Laurentian, or Primary	
I.	Primal slates	Potsdam sandstone	Silurian Age.
"	" sandstones	" "	
II.	Auroral calc. sandstone	Calciferous sand-rock	
		Chazy limestone	
"	Auroral magnesian limestone	Birdseye "	
"	Matinal limestone	Black River "	
		Trenton "	
III.	Matinal black slate	Utica slate	
"	" blue "	Hudson slate	
IV.	Levant gray sandstone	Oneida conglomerate	
"	" red "	Shawnyunk grit	
"	" white "	Medina sandstone	
V.	Surgent red shale	Clinton group	
"	(wanting in Pennsylvania)	Niagara limestone	
"	" "	Onondaga salt group	
VI.	Scalent limestone	Lower Helderberg limestone	
"	Pre-meridian limestone		
VII.	Meridian sandstone	Oriskany sandstone	Devonian Age.
"	(wanting in Pennsylvania)	Cauda-galli grit	
"	" "	Schoharie grit	
VIII.	Post-meridian limestone	Upper Helderberg	
"	Cadent lower black shales	Marcellus shales	
"	" " olive shales	Hamilton "	
"	" upper black slates	Genesee "	
"	Vergent gray sandstone	Portage group	
"	" olive shales	Chemung "	
IX.	Ponent red sandstone	Catskill "	
X.	Vespertine	" "	
XI.	Umbral red shale	" "	Wanting in N. Y.
XII.	Seral conglomerate	*Carboniferous*	
XIII.	COAL-MEASURES	"	

Of the sixty-six counties in Pennsylvania, the following twenty-five contain no coal whatever, viz.: Philadelphia, Delaware, Chester, Montgomery, Bucks, Northampton, Lehigh, Berks, Lebanon, Lancaster, York, Adams, Franklin, Cumberland, Mifflin, Juniata, Perry, Snyder, Union, Montour, Monroe, Pike, Wayne, Susquehanna, and Erie. They are all situated in the southeastern part of the State above described, except Erie, which is in the northwestern corner. The anthracite coal of Pennsylvania is situated principally in the four counties of Dauphin, Schuylkill, Carbon, and Luzerne; with smaller quantities, the borders of the basins in Northumberland and Columbia Counties, and there is semi-anthracite coal in Sullivan and a little in Wyoming County.

FIG. 28.



Map of Pennsylvania, showing the Positions of the Axes of the Folds in the Strata.

Six counties contain detached fields of semi-bituminous coal: Bradford, Lycoming, Tioga, Huntingdon, Bedford, and Fulton.

The following twenty-seven counties in the western and northwestern part of the State contain bituminous coal, a portion of which along the eastern margin of the field is semi-bituminous, viz.: Somerset, Fayette, Greene, Washington, Westmoreland, Cambria, Indiana, Armstrong, Alleghany, Beaver, Lawrence, Butler, Clarion, Jefferson, Clearfield, Blair, Centre, Clinton, Cameron, Elk, Forest, Venango, Mercer, Crawford, Warren, McKean, and Potter, or in all forty-one coal-producing counties. Of so vast a coal-region with a very intricate structure, only a general account can be given in the limits of this volume. Its total area is 12,222 square miles, besides 80 miles in Broad Top, and 472 in the anthracite fields, making a total of 12,774 square miles of coal of all kinds in Pennsylvania.

General Geological Sketch.

The counties of Greene and Washington, and parts of Alleghany and Westmoreland, in the southwestern corner of the State, although not the highest above the sea, are much the highest geologically. This is owing to the strata of rock dipping or sinking into the earth, from the northeast toward the southwest, faster than the surface descends. Taking our position on the highest land in Greene County, we shall there observe beds of shale and sandstone, and several thin seams of coal, that are not to be found in any other part of Pennsylvania; but, if we trace them toward the north or northeast, we shall observe that they rise nearer the surface until they run out, and lower seams of coal can be seen to appear in the ravines and sides of the hills, which again give place to others in their turn. Near the West Virginia line, on the Monongahela River, below the small seams mentioned, is a fine bed of coal, six feet thick, called the Waynesburg, which is above the Pittsburg bed. (*See* fig. on page 224.) Going northward down the river, this soon gets higher and higher in the hills, until it runs out; and the Pittsburg bed, which is about 228 feet lower, and is near the water's edge at Brownsville, gradually rises until, at Pittsburg, it is 300 feet above the river, and in the northern part of Alleghany County it disappears on the tops of the hills. Then in going farther north we find the country covered with a series of red and blue shales and sandstones with no good

coal-seams, but soon after, in ascending the Alleghany River, the upper seam of the lower coal-measures appears in the bottom of the river, which is the lowest ground; and so on in going northward each of the lower seams appears, spreads east and west, is seen for a certain distance, and then runs out in the air. In the more northern counties of the State only the lower seams of coal are found on the highest summits of the mountains, and that only in detached fields or comparatively small fragments of basins.

This coal-region must be viewed in three aspects: First, as it was formed by the various strata of rock and seams of coal being laid down upon each other; second, as it was affected by internal forces, which heaved up portions of it along certain lines in an irregular manner, in a waving form, throwing it into a series of great arches succeeding each other from the south-east toward the northwest; and thirdly, as it was afterward affected by forces acting on its surface, which removed parts of the upper strata and coal-seams, exposing lower rocks and coal-seams, leaving only fragmentary portions, or cutting deep channels through the coal-measures or rocks which are now occupied by rivers and smaller streams.

1. *The Series of Coal-Strata.*—The lower coal-measures, by which are meant the rock-strata and coal-seams, are about 600 feet thick on the Alleghany River and the counties adjoining, and contain five principal seams of coal, designated in the ascending order by the letters A, B, C, D, and E, of which B and E are the largest and most reliable. At least three-fourths of the field contains only these lower coal-measures. Next above occur the Barren Measures, which are from 407 to 578 feet in thickness, including two thin seams of coal, F and G, one or two feet thick. Above these occur the upper coal-measures, from 200 to 240 feet thick, the bottom of which is the first seam of coal, which is the famous and very productive Pittsburg seam H, above which, as before mentioned, is the Waynesburg. Above the upper coal-measures are 900 to 1,000 feet more of strata in Washington and Greene Counties, with some thin seams of coal, but, as none of them are workable in this state, these may be properly called the upper Barren Measures. There is in the northwestern part of the State a

series of coal-measures below that above described as the lower coal-measures, and some coal also occurs in a similar situation in a few other localities, but this is only of rare occurrence. The bituminous coal-seams of Pennsylvania are never as large as the anthracite. They vary in thickness from one to two yards, and in a few instances in some localities they are three and four yards in thickness. Three feet of pure coal is considered a workable seam.

2. *Upheavals into Coal-Basins.*—Throughout the whole field east and northeast of the Pittsburg district, and to a less degree in the latter, the rock-strata and coal-seams are not horizontal, nor do they even form one general basin, but they are formed into a number of vast flexures or waves, the lines of which run in a general northeast and southwest direction, dividing the field west or northwest of the Alleghany Mountain into six great troughs or basins. The first two on the east side run across the whole State, and the first is subdivided in Somerset County by Negro Mountain; the second is bounded by Laurel Hill and Chestnut Ridge toward its southern end. The other four are not observed in the counties in the southwestern part of the State, where they strike the Barren Measures. As the upper coal-measures in the Frostburg (Maryland) region are greatly affected by these flexures, the age of these disturbances is evidently later than that of the upper coal-measures. Their absence in the Pittsburg region is therefore because they never extended to that locality. But that district has some smaller subdivisions of less elevation.

The result of this peculiar structure of these ridges with the basins between them, together with the general rising of the strata as we proceed northward, is, that the coal-basins become shallower and contain fewer coal-seams within them in a northeastern direction. Toward the south the coal-seams arch over from one basin to another, but farther north the coal-strata on the backs of the upheaved portion are broken up and washed away, and coal is only found in the bottoms of the troughs, in long fingers of coal, as in Clearfield, Jefferson, and Forest Counties; and finally, farther northeast, these are broken into detached patches irregularly disposed and occupy-

ing only the highest knobs on the highest mountains, as at Blossburg and Towanda.

3. *Denudations.*—But the topography of this whole coal-field is only in some localities governed by its geological structure. Over much of its area another important feature is, that it is everywhere trenched by ravines and by more or less deep valleys, the result of extensive denudations by water, and cut out without reference to the flexures described, and the basin or rather trough-like structure is not observed in the general features of the country, but only in the position of the rocky strata. This peculiar topographical and geological structure, while it has robbed the State of much of its mineral fuel, has given ready açcess to the coal, and is of great importance for the purpose of its development.

This general preliminary view of the whole field is first given, in order that the more full descriptions which follow may be better understood. The field will be hereafter described by its natural divisions into basins, the importance of which will have been observed in the fact that in these localities, the centre lines as it were of these great inverted arches, is found the largest quantity, and in the more northern portions of the field the only coal that has escaped the general destruction.

Northeastern Part of the Field.

From the southern boundary of the State, in Somerset County, to the North Branch of the Susquehanna, in Luzerne County, the southeastern base of the Alleghany Mountain constitutes a remarkably well-defined margin of the coal-field. It forms the east line of the northern half of Somerset, and the whole of the east line of Cambria, and includes the western townships of Centre. But, on the north, it is a much more undulating chain, of more broken outline, too irregular to admit of description, which stretches from Towanda almost due westward by Blossburg, Smethport, and Warren, and thence with a greatly reduced height is deflected somewhat to the south by Meadville and Greenville until it crosses into Ohio. Along the northern side of the basin from the Chemung group upward in the series to the coal-measures inclusive, the strata have a gentle

dip toward the south, leading us into higher and higher beds of rocks as we recede in that direction from the New York line, where the shales and thin-bedded sandstones of that group cover the surface over all the southwestern parts of that State. In Crawford and Mercer Counties, where the lower strata lie to the northwest of the coal, the prevailing dip of all the rocks of the series is toward the southeast, but along the Alleghany Mountain, or on the southeastern margin, their prevailing inclination is either northwestward or northward, being thus in every instance inward as respects the central portion of the great trough enclosing the coal. But while this is strictly true, as a general rule, of the strata along the edges of the basin, it is always necessary to observe that within this boundary there exist a number of anticlinal axes, some of them of great length and elevation, others low and insignificant, forming throughout the entire region an almost endless succession of more or less gentle undulations. The northeastern part of this great plateau is a very interesting part of it, as it extends, in that direction, five long, projecting spurs, each having the structure of an elevated flat basin, bounded on both sides, and at its rounded northern extremity by a steep slope descending into an external valley. These five spurs are so many partially-insulated coal-basins, the extremities merely of the long, parallel belts of the coal measures which farther toward the southwest merge together and deepen into the great bituminous coal-field of the State. They are the result of five anticlinal waves of the strata entering the region from the northeast and expiring within the coal-fields. The structure of these mountain-basins and anticlinal valleys may not be at once apprehended by the reader without this further explanation. The crust of the earth seems to have been folded into a series of waves, like sheets of paper pressed lengthwise in a man's hands, until, in this northeastern part of the coal-field, the crust was broken at the top of the waves. These broken rims of the basins became then the more destructible parts, the fissures of the broken mountains being here deepest, and, when exposed to the great diluvial currents poured southward, the soft or broken strata were in a position or state to be most easily ploughed up, and carried off by the action of denuding water, which has first planed them down, and then,

finding its way to the soft mud-rock or shales beneath, it cut deep valleys, where, but for this agency, there would have been the highest mountains. At the same time the synclinal or bottom of the basin was protected from being washed away by the position in which it was thrown, and by the comparatively sound although somewhat bent form of its strata. Hence, we have in this northeastern part of the Pennsylvania coal-region, in the counties of Bradford, Tioga, Lycoming, Potter, etc., our valleys on what were to have been the summits of the mountains, and our coal-basins on the summits of the present mountains, which were the ancient valleys.[1] Another curious fact is, that every one of these five mountain-spurs, in which the great coal-field terminates, is cut to its base by one or more cross valleys or ravines through which large streams flow, such as the West Branch of the Susquehanna River, and its tributaries, Loyalsock, Lycoming, and Pine Creek. While the general surface of the upper table-land is level, these ravines are many hundred feet in depth, and with very steep slopes. The course of the valley of the upper North Branch and of the West Branch of the Susquehanna River give us an incorrect idea of the real mountains and valleys as originally formed in the structure of the solid portions of the earth or geological strata, which run from northeast to southwest across the State through its great bituminous coal-region.

The traveller along the branches of the Susquehanna, particularly on the North Branch, must be struck by its singular course in utter disregard of the old mountains which seem to have once run across its stream. Few of the Appalachian rivers, says Prof. Rogers, can boast of a greater amount of attractive valley-scenery than the North Branch presents throughout its whole course from the Great Bend near the State line in Susquehanna County through Southern New York, and thence through Pennsylvania to the Wyoming Valley. It owes its eminence in part to the beautiful manner in which its terraces of northern drift or gravel have been strewn and shaped at the last retreat or rush of waters across the continent.

[1] See plate on page 167.

IX.

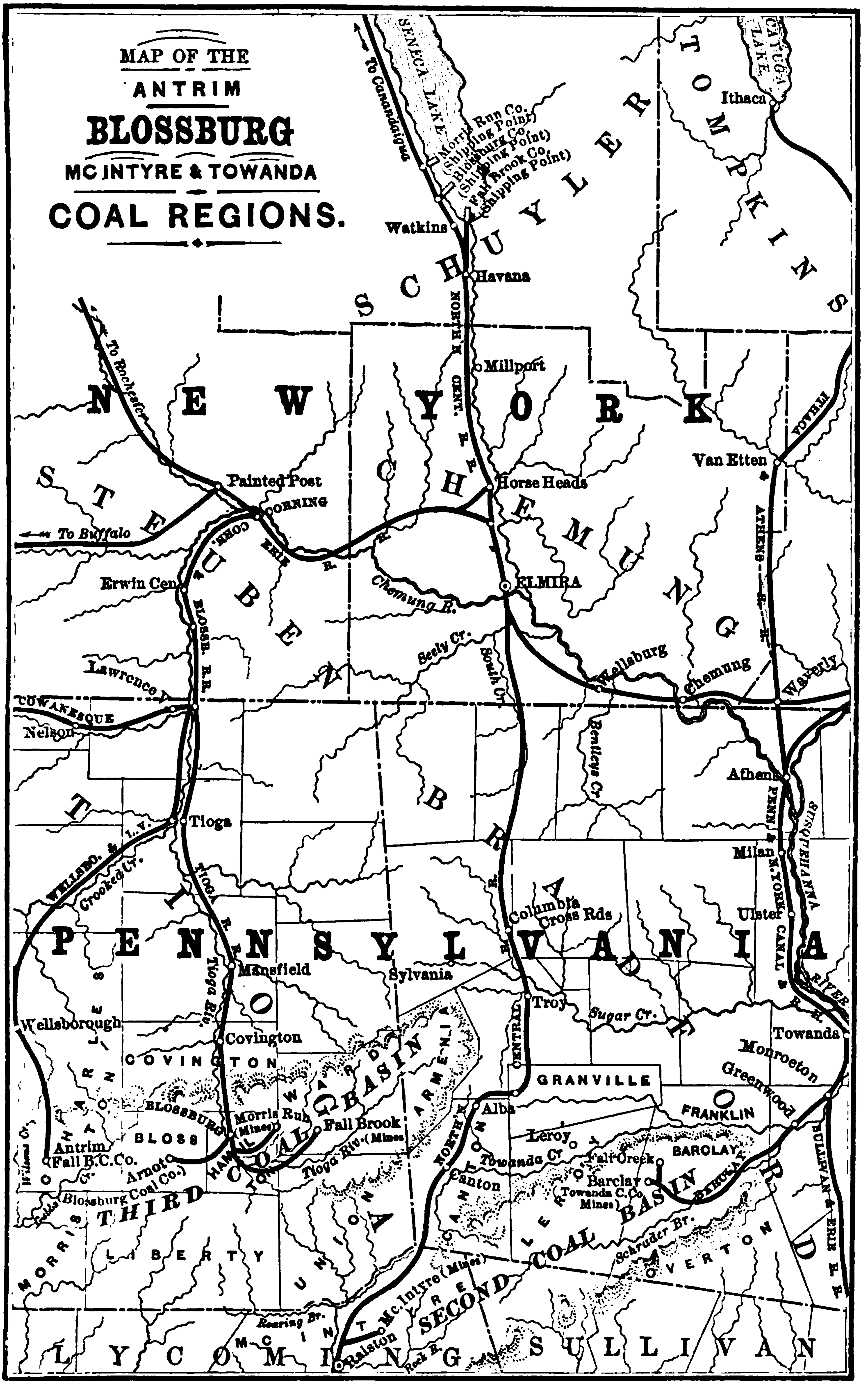
SEMI-BITUMINOUS COAL-REGIONS.

Before proceeding to the description of the great bituminous coal-field of Western Pennsylvania, as it is divided into basins, it will be convenient to describe some of the apparently detached coal-districts along the northern borders, which, although situated in the second and third basins, yet from their vicinity to each other, the similarity in the quality of the semi-bituminous coals they produce, and which all goes into the Northern market, may very properly be viewed and considered together. These are the Blossburg region in Tioga County, the McIntyre at Ralston in Lycoming County, and the Barclay or Towanda in Bradford County.

Several other semi-bituminous coal-districts situated farther south, and along the eastern margin of the Alleghany Mountain, in the first basin, will be described in this chapter, namely: the Snowshoe, in Centre County; the Phillipsburg, on the line between Centre and Clearfield Counties; Johnstown and others, in Cambria County; and the Broad Top, in Huntingdon and Bedford Counties. After disposing of these, the main body of the coal-field farther west, producing common bituminous coal, can be described in a connected narrative.

1. BLOSSBURG.

The approach to the Blossburg region is from the north. The Tioga River rises in the ravines that are cut down through the coal-basin, and unite at that village. Thence the Tioga Valley runs due north to Corning, New York, following the anticlinal axis between the third or Blossburg, and the fourth


MAP OF THE
ANTRIM
BLOSSBURG
MC INTYRE & TOWANDA
COAL REGIONS.
SENECA LAKE
CAYUGA LAKE
To Canandaigua
Morris Run Co. (Shipping Point)
Blossburg Co. (Shipping Point)
Fall Brook Co. (Shipping Point)
Watkins
Havana
Ithaca
SCHUYLER
TOMPKINS
NORTH'N CENT. R. R.
Millport
NEW YORK
To Rochester
Painted Post
CORNING
To Buffalo
STEUBEN
CHEMUNG
Horse Heads
Van Etten
ITHACA
ATHENS R. R.
ERIE R. R.
CORN. & BLOSS. R.R.
Erwin Cen
Chemung R.
ELMIRA
Seely Cr.
South Cr.
Lawrence
Wellsburg
Chemung
Waverly
COWANESQUE
Nelson
Bentleys Cr.
Athens
BRADFORD
TIOGA
Tioga
WELLSBO. & L.V.
Crooked Cr.
TIOGA R. R.
Milan
SUSQUEHANNA RIVER
PENN. & N. YORK CANAL & R. R.
Columbia Cross Rds
Ulster
PENNSYLVANIA
Mansfield
Sylvania
Tioga Riv.
Wellsborough
Troy
Sugar Cr.
CHARLESTON
Covington
COVINGTON
WARD
ARMENIA
Towanda
Monroeton
Greenwood
CENTRAL
GRANVILLE
BLOSSBURG
Morris Run (Mines)
Alba
FRANKLIN
BLOSS
Fall Brook
Tioga Riv. (Mines)
Leroy
Antrim
Fall B.C.Co.
Arnot
(Blossburg Coal Co.)
HAMILTON
THIRD COAL BASIN
Towanda Cr.
Fall Creek
BARCLAY
Canton
Barclay
(Towanda C.Co. Mines)
SULLIVAN & ERIE R. R.
Wilson Cr.
MORRIS
LIBERTY
UNION
CANTON
LEROY
OVERTON
Schrader Br.
SECOND COAL BASIN
Mc.Intyre (Mines)
Roaring Br.
MCINTYRE
Ralston
Rock R.
LYCOMING
SULLIVAN

or Cowanesque basins. This valley affords an admirable route for a railroad, and just in the right direction toward the populous and coalless State of New York. Seventy-five miles of railroad carries the coal to Seneca Lake, where it is received into 200-ton boats that carry it, by the Erie Canal and its branches, to Buffalo, Oswego, Troy, Albany, and all intermediate places.

The long, uniformly straight lines which characterize the eastern margin of the Alleghany Mountain are nowhere found around this its northern margin. On the contrary, we find long, narrow prongs, with long, narrow coal-basins on the summit of each. But these finger-points of mountains are so cut by ravines and deep valleys that only a geologist can define the lines of the coal-basins by observing the inclination of the strata, and tracing them for long distances. The general inclination of the formations is southwestward, and, on the State geological map of New York, a beautiful section is given from the St. Lawrence River, at Ogdensburg, to Blossburg, Pennsylvania, showing how in that short distance we can pass over every formation, all of them represented, and rich in fossils, from the primary system, through all the Silurian and Devonian, up to the Carboniferous.

So new is the coal business in America, that, although this region was only developed by the building of a railroad in 1840, it is one of the oldest of our productive coal-regions, and its annual production is now rapidly approaching 1,000,000 tons, all coming from three mines immediately around Blossburg. There are few other places in the United States where, at present, there is so large a production of bituminous coal from within the same limited area. As this is the first bituminous coal-district to be described, after giving its geology, some particulars will be entered into in regard to the mines, which will serve to furnish the reader with a general impression in regard to the coal-works of all the other bituminous coal-regions. These details will, therefore, not require to be repeated in other cases.

Richard C. Taylor, of Philadelphia, was the most distinguished geologist of his time, and the author of a large and valuable work called "Statistics of Coal," published in 1848,

containing a history of the coal-regions and coal-trade of the whole world. A revised edition, by S. S. Haldeman, was published in 1855. In the year 1832, Mr. Taylor made a mineral and geological survey of the Blossburg region, and a survey of the Tioga Railroad, which was subsequently built from Corning, New York, to Blossburg, Pennsylvania. His account of the coal and iron-ore in this region, which was printed at the time, has been confirmed by the discoveries and mining developments since made, and the substance of his report will be here given as a proper description of the Blossburg region, which is the northern extremity of the third basin of Rogers:

"In taking a general view of this district, it will be seen that the Tioga Valley, at Blossburg, forms a kind of central point or area whence diverge irregularly a number of small valleys or deep ravines. All these valleys, to the number of twelve, rise with a rapid inclination above the level of this area until they intersect the mineral strata of the surrounding mountains, at elevations between the lowest and the highest, of from 200 to more than 380 feet, and the usual elevation of the summits or table-lands being 500 or 600 feet above Blossburg. Coal and iron-ore of different qualities prevail extensively, and, where thus intersected by deep ravines, occur under the most favorable circumstances for mining and for transmission upon railroads. The approaches and position of most of these sites were surveyed, sections of the mineral beds and the intervening strata were drawn, about 25 miles of the surrounding ravines were surveyed and explored, levels taken through the woods for the purpose of establishing the identity and horizontality of the beds, and the area around Blossburg, comprehending a circle about five miles in diameter, was examined in almost every point. Almost every valley to which we have referred is capable of maintaining its contributions of these important products to the principal line."

Three of these little valleys diverging from Blossburg have since become the routes for three separate branch railroads to the various mines of the three coal companies who now mine and send to market the celebrated Blossburg coal. The first on the east side is the Morris Run branch, four miles in length, to the mines of the company bearing that name. The second,

also on the east side, runs up the valley of Fall Brook six miles to the mines of the Fall Brook Coal Company, situated nearly east from the Morris Run. The third is the branch railroad of the Blossburg Coal Company, which, also diverging from the main Tioga Railroad at Blossburg, curves off to the westward, passing up the valley of Johnson's Run four miles, to the mines of that company, at Arnot, which is nearly due west from Morris Run and Fall Brook, and the three lying nearly on a due east and west line. (*See* map of Blossburg region, page 125.)

Mr. Taylor incidentally mentions that the first coal dug in the district was opened in the fifth coal-seam, by Aaron Bloss, an early settler at Blossburg, whose name was given to the mining village which afterward sprung up, and also to the township, and has thus been immortalized and become known for thousands of miles, and will go down in the history of the coal-trade so long as Blossburg coal is used, or wherever the name serves as the generic name for this species of coal.

Enough was ascertained by Mr. Taylor of the geological structure of the country to show that no serious impediments to practical operations can be contemplated from the prevailing inclination of the strata. On the contrary, he remarks, it is well known that such a depression is as likely to facilitate as to retard an extensive system of mining when the sites for commencing these operations are judiciously selected. He reports the existence of as many as nine different beds of coal, varying in thickness from 1½ to 4¾ feet, and one as much as 6½ feet, at the outcrop, within a range of about 250 feet of rock-strata. He assumed the modest quantity of 100,000 tons as the maximum future annual production, which, during the last year, has been exceeded by more than eightfold that quantity. Some of the districts beyond the limits of his surveys, and which, from a mere reconnaissance, he reported as containing coal, have since proved to be very productive, among which are the lands of the Fall Brook Coal Company. The verification, after so many years, of the report made by Mr. Taylor at a period, forty years ago, when the whole country was covered by forests, and so little opportunity for examination was afforded by actual mining on the ground, as to the

locality, the quantity and quality of the coal, is calculated to inspire us with great respect for the opinions of well-educated, experienced, and really scientific geologists.

After referring to the coal-seams as apparently intersected, five or six miles from Blossburg, in the valley as far as beyond the forks of Fall Brook, he points out the existence of coal on the Lycoming Creek at Ralston, where the McIntyre mines now are, also on the head-waters of Towanda Creek, where Barclay now is, and on the Loyalsock Creek, where the Sullivan County field has since been developed, and pronounces that at Towanda as "in all probability forming the extreme northeasterly limits of the bituminous coal-region of Pennsylvania," as it has proved to be.

No Coal north of Blossburg.—As this geological report was made long before any State geological survey had been begun in New York or Pennsylvania, and while the science was really in its infancy, there were not wanting those who thought that coal might exist in the State of New York, and this is also mentioned, in the preface to the Geological Report of that State, as a prevalent opinion at the time among non-scientific men. As a practical lesson worthy of preservation, the following calculation was made by Mr. Taylor, showing the impossibility of the occurrence of coal north of Blossburg toward or in the State of New York:

"Beyond Blossburg toward the north it would be in vain to search for the coal-strata; for, independent of the geological character of the country being dissimilar from the Carboniferous formation to the south, there is no ground lofty enough to contain them in that direction. Near the State line a mountain must be 4,100 feet high above the Tioga River to receive them, supposing those seams to be perfectly horizontal. Sufficient data, however, are at hand to show that, as the dip of stratification is almost without exception toward the south, we must add the amount of dip or inclination to the absolute altitude of the highest land there, ere it would be elevated enough to be capped with the coal-measures. We need not here apologize for the introduction of these details, when it will be admitted that an attention to the inclination and direction of the rocks is of essential importance toward an accurate knowledge

and development of the geological structure of any mineral region." He then calculates the dip of the rocks, from Blossburg to the State line, and shows that it would require a mountain 5,125 feet (or nearly a mile) high, to contain the coal-measures. Then tracing the southern dip of the strata into the State of New York to the Narrows near where Corning now is, he shows that 1,050 feet more would be required there, or 6,175 feet, whereas the hills are not one-tenth of that height. He extended his examination some 60 miles farther north into the State of New York, or 100 miles north of Blossburg, and found a general depression of the strata toward the Tioga coal-field, although they were in some places horizontal.

"This calculation is entered into with a view of showing the futility of the expectation, not uncommonly expressed, of tracing these coal-beds in a northerly direction beyond the limits at which they are at present discoverable. Consequently there is no probability that any portion of these mineral beds are prolonged in that direction, and we must continue to regard the district of Blossburg as the real northern termination of the great Alleghany coal-field."

All of this was fully confirmed by the Geological Survey of the State of New York, published ten years later, in 1842, and in the section given of the strata from Ogdensburg, New York, to Blossburg, before referred to, showing to the eye what Mr. Taylor had described in his report in 1832. It was also in this survey of the Blossburg region that Mr. Taylor first discovered in America, in the valley of Tioga River, the Old Red sandstone, since called the Catskill group, and thus furnished one of the first links in the chain, or the first reliable starting-point in American geology, and for which Prof. Hall, in his New York report, gives him full credit.

The coal-mines at Blossburg were visited by Sir Charles Lyell, the celebrated English geologist, in 1841, and, in his "Travels in North America," he gives the following interesting account of them: "It was the first time I had seen the true coal in America, and I was very much struck with its surprising analogy, in mineral and fossil character, to that of Europe; the same white grits or sandstones as are used for building near Edinburgh or Newcastle; similar black slates, often bituminous,

SECTION FROM OGDENSBURG, N. Y., TO BLOSSBURG, PA.

FIG. 24.

Medina Sandstone

Gray Sandstone

Mexico

Hudson River Group

Pulaski

Utica Slat

Trenton Limestone

Black River Limestone

Watertown

Birdseye Limestone

Calciferous Sandstone

Potsdam Sandstone

Theresa

Primary System

Potsdam Sandstone

Ogdensburg

Calciferous Sand-rock

Calciferous Sand-rock

FIG. 23.

Catskill

Chemung and Portage

Tully Limestone

Hamilton Group

Helderberg Limestone

Salina or Onondaga Salt Group

Niagara Limestone

Clinton

Blossburg Coal Region

ga River,
Blossburg

N. Y.
ne.

ntral R. R.

R.

with the leaves of ferns spread out, as in an herbarium, the species being, for the most part, identical with British fossil plants; seams of good bituminous coal, some a few inches, others several feet, thick; beds and nodules of clay, iron-stone, and the whole series resting on a coarse grit and conglomerate containing quartz-pebbles very like our Millstone grit, and often called, by the American as well as English miners, 'farewell rock,' because, when they have reached it in their borings, they take leave of all valuable fuel. Beneath this grit are those red and gray sandstones corresponding in mineral character, fossils, and positions, with our Old Red.

"I was desirous of ascertaining whether a generalization, recently made by Mr. Logan, in South Wales, could hold good in this country. Each of the Welsh seams of coal, more than ninety in number, has been found to rest on a sandy clay or firestone, in which a peculiar species of plant, called *stigmaria*, abounds, to the exclusion of all others. I saw the *stigmaria* at Blossburg in abundance, in heaps of rubbish extracted from an horizontal seam. Dr. Saynisch, the president of the mine, kindly lighted up the gallery that I might inspect the works, and we saw the black shales in the roof adorned with beautiful fern-leaves, while the floor consisted of an under-clay, in which the stems of *stigmaria*, with their leaves and rootlets attached, were running in all directions. The agreement of these phenomena with those of the Welsh coal-measures, 3,000 miles distant, surprised me, and led to conclusions respecting the origin of coal from plants, not drifted, but growing on the spot, to which I shall refer hereafter." He accordingly wrote a letter to Dr. Fitton, on "The Blossburg Coal-district and *Stigmaria*," which appeared in the proceedings of the Geological Society of Great Britain, vol. iii., p. 554, dated September 2, 1841. Sir Charles Lyell afterward visited the Summit Hill Mine, at Mauch Chunk, and discovered the same fossil plants in its roof and floor, indicating the identity in age of the bituminous and anthracite coal-beds.

An illustration of the fossils referred to by Sir Charles Lyell is given on page 135, which was accurately copied, and of exactly the natural size, from an unusually perfect fossil found, in 1871, in the roof-slates of the Blossburg Coal Company's mines

1 FIG. 28 3 2 1

3

3

IDEAL VIEW OF A CARBONIFEROUS FOREST AND MARSH.

1. *Sigillaria*.—So named from the leaf scars like *seal* impressions on the ridges or raised flutings of the trunk. [These should have been in double spirals, smaller and closer together.] 2. *Lepidodendron*, or scale-tree.—So called from the *scale* like arrangement of the leaf-scars that adorn the stems. 3. *Stigmaria*.—So named from their regularly pitted or dotted surface. [They are here improperly represented as a dome-shaped plant with radiating roots—an old error. It is now well known that the Stigmaria is the stump of the Sigillaria and Lepidodendron, with radiating roots.]
As a general view, it is a good one, and gives a proper idea of the marshes in which the vegetable matter grew which formed our coal.

at Arnot. The reader should also refer to an ideal view of a marshy forest of the coal-period, given on page 133, showing a variety of plants of which the fossils occur in coal-shales.

The Tioga Railroad, from Blossburg to the New York State line, and its extension, called the Corning & Blossburg Railroad, from the State line to Corning, New York, the two together 41 miles in length, were completed in 1840, and 4,235 tons of coal sent to market, which were followed by 25,966 tons in 1841. Previous to that time, the whole sea-coast used the Richmond (Virginia) coal for blacksmithing and the manufacture of wrought-iron in all its branches. The Cumberland (Maryland) coal first found its way to market over the Baltimore & Ohio Railroad, in 1842. The Blossburg region was therefore developed at an early period in the history of the coal-trade, in fact, before coal of any kind was needed in large quantities for any purpose, there being, at that time, only 800,000 tons per annum of anthracite coal sent to market.[1]

Up to the year 1860, the use of Blossburg coal was confined, with unimportant exceptions, to blacksmithing and the use of three rolling-mills at Troy, New York, wood being the fuel used for steam purposes, and that in a small way only, in the State of New York. In 1861 the tonnage amounted to 112,712 tons, besides 40,835 tons from the Barclay region. From that period, being the commencement of the war, manufacturing, of various kinds, requiring the use of coal, sprung up in the interior of the State of New York, especially rolling-mills, the railroads commenced to use coal instead of wood in their locomotives, and the salt-manufacturers at Syracuse also substituted coal for wood in their salt-blocks.

The general geological section in the Blossburg region consists of 333 feet of strata, including five workable seams of coal, four of which have been worked at various times in the district, and three of them are now worked. The lowest, or Coal A, known among the miners as the Bear Creek vein, is from 3 to 3½ feet thick, and was worked, as well as the Bloss seam, at the

[1] The late James R. Wilson, of Tioga County, Pennsylvania, and formerly of Philadelphia, was the pioneer in this, which was one of the boldest enterprises of those days; and his brother, G. R. Wilson, of Buffalo, New York, was the first, and for more than thirty years has been one of the largest, dealers in Blossburg coal.

FIG. 27.

NEUROPTERIS FLEXUOSA, literally, "bending nerve-fern," so named from the veins of its leaflets. The fossil fern, here represented of the natural size, was taken from the roof-slates of coal-seam D, at the mines of the Blossburg Coal Company, at Arnot, Pennsylvania.

old Blossburg mines, at that village, by W. M. Mallory, previous to 1858. It produced a good steam-coal, but it frequently thinned out, and it is not now worked in this region. (*See* Section at Arnot, page 137.)

The most important seam, and which is worked at all the mines, is B, which is called the Bloss vein, which is from 13 to 29 feet above A. From this seam most of the coal of the region is produced. It is sometimes interlaid with a thin seam of slate, and, when this occurs, an allowance is made, to the miner, of a certain sum, for each inch of slate, added to his usual price per ton for mining. This system is a very just one, on account of the additional labor. At other localities, in the same mines, this slate disappears, and the seam presents a clean bed of pure coal, from 4½ to 5½ feet in thickness.

The next seam, which is worked to a limited extent, is 25 to 30 feet higher, sometimes less, and will here be called Coal b, but, on account of the heavy bed of fire-clay on which it rests, it is commonly called the Fire-clay vein. It is a variable seam, from 1½ to 3½, and sometimes 5, feet thick, when impurities occur in the middle. It appears to be a rider or satellite of seam B. It produces good coal, and, when it appears in its best form, it is a valuable seam. It is now being mined only in portions of the field. Coal C occurs from 7 to 18 feet higher, and produces a species of cannel-coal. In Western Pennsylvania, this seam C is the great deposit of cannel-coal, wherever that variety is found. But cannel-coal is always liable to become degraded into bituminous shale, and that is its character at Blossburg. This seam is always stigmatized, in this region, as the Dirty vein or the Slate vein. It is regarded as worthless, and has never been mined.

Next in the ascending order, at an elevation of from 7 to 20 feet above the last, is a small seam, only useful as a geological landmark, Coal c, or, as the miners call it, the Monkey vein, on account of its small size, which is from 1½ to 3½ feet. It has never been opened for mining purposes.

Coal D is called at Blossburg the Seymour vein, in honor of ex-Governor Seymour, who was a land-owner where it was first wrought. It is from 3 to 4½ feet in thickness, always free from slate, and produces a bright, beautiful-looking coal, of a

VERTICAL SECTION OF THE COAL-MEASURES.

AT ARNOT.

(Scale 60 feet to an inch.)

AT McINTYRE.

tone.

k Vein.

ck.

ein, 3 feet.
Shale.

dstone.

4 inches.

ne.

one.

n, 3 feet.

2 feet.

Som
w

lay Vein.

andstone

Alv
wo

4½ feet.

s.

For
wor
Blos

Coal.

cks.

e Sand-

2 inches.

columnar structure, and an excellent blacksmith-coal. It is worked in a portion of the region. Its elevation above the last-named seam is from 30 to 67 feet, but, like all the other intervals of rock, this is sometimes much less. Its elevation above the Bloss seam is from 114 to 162 feet. About 50 feet above the last is Coal E, commonly called the Rock vein, on account of the heavy, coarse rock over it, which is sometimes conglomeritic. This seam is from 2¼ to 3 feet thick, and, in a few localities, it is of a better size, but it has never been worked. Fifty-six feet of rock has been measured over this seam, but without coal, and it is not improbable that the foregoing series embraces the whole of the lower coal-measures of Pennsylvania. Several smaller seams of coal, of about one foot in thickness, sometimes occur, of which no mention has been made.

The sections at various places in this and the neighboring districts prove what has been before noticed, the remarkable uniformity of the coal-seams from mine to mine, even the very small ones all preserving their characteristics everywhere sufficiently to be identified by the miners after a very little examination. On the contrary, the intervals of rock undergo constant and rapid changes, both in their size and the materials of which they are composed. Sandstones, shales, and conglomerate, are substituted for each other in the same geological horizon, so that no enumeration that could be made of them would be of much value. If they are governed by any law, the strata of rock seem to thicken up in passing along the basin from northeast to southwest, and the materials of which they are formed must have been carried by numerous currents running across the basin, or northwest and southeast, so as to afford a variety of rock formed of sand, mud, and pebbles, on the same geological level in going from northeast to southwest, or down the present basin.

Fall Brook Village and Mines.—The first coal was shipped from the mines of the "*Fall Brook Coal Company*" in March, 1860, and there have been produced and shipped from them 1,951,600 tons to January 1, 1872. The country for several miles around was a pathless wilderness, covered with heavy timber. There are now at Fall Brook 238 tenement-houses, all owned by the company, costing $120,000; 20 other buildings, including an hotel, store, offices, barns, storehouses,

and shops, costing $35,000; coal-shutes and other coal-fixtures, $50,000; steam saw-mill, $13,000; and the clearing of land cost $18,000. These, it will be observed, are all outside expenses preparatory to mining coal, while a vastly larger sum has been expended underground. The opening of the mines, before commencing the mining proper, cost $75,000. What is called mining plant, consisting of mine-cars, mine-locomotives, tools, iron, etc., cost $50,000, besides $14,000 for mules, horses, wagons, etc., necessary for carrying on the business, and $35,000 for iron in mines for tracks, frogs, switches, etc.

These items will give the reader an idea of the expenses to be incurred in preparing to mine coal on an extensive scale, to all of which must be added the cost of the coal-land and an extensive body of timber-land, the construction of railroads, the purchase of railroad-cars, locomotives, and building and furnishing of machine-shops, besides working capital for carrying on the business of mining, transporting, and selling coal. It is necessary to have at least two acres of timber-land for one of coal-land, in order to supply lumber and timber for mining purposes, such as props, for the safety of the miners, and the protection of the mines.

But the mines are the important part of the establishment. The method of working the mines is called square work. The gangways are driven seven feet wide, and have back or parallel headings six feet in width at right angles to the gangways, there being 10 yards of pillar left on each side of the gangways. The breasts, or rooms, are worked off the back headings 18 yards wide, forming two breasts together, or in each range, and they are driven 60 yards in distance, and a pillar 15 yards wide is left between each range of breasts. The breasts are worked thus narrow because of an upper seam of coal 40 feet above the lower one, which is worked simultaneously, and the pillars are left closer together to insure the safety of the upper seam and the men and operations there. In another drift, where it is not intended to work the upper seam, the breasts are worked 24 yards wide, and pillars 18 yards wide are left between each range of breasts.

After the breasts are all worked out in this manner over a given territory, the place is finished by taking out the pillars

also. This is done by first splitting them, by driving a heading through the middle of them, six feet wide; then commencing inside or at the farther end, the remainder of the pillar is mined out by drawing back the pillars, which are about 20 feet wide, on each side of this heading, which affords a place of safety for the miner and the mine-car should the top come down. By this method the loss of coal is practically nothing, as not more than two per cent. of these pillars is lost in drawing them, while, of the much larger amount mined in the breasts, headings, and gangways, scarcely any thing is lost. This method of mining, however, can only be practised where a good, hard, self-sustaining roof is found, like that at Fall Brook.

The maximum quantity of coal a good miner will cut is six tons per day, or 150 tons per month of 25 days, although but few miners work more than 22 days per month. In headings, a fair average miner will drive about 28 yards per month, say about 110 tons of coal, and for this work he is paid by the yard as well as by the ton.

In one of the drifts, where mules are used, the tram-road has a gauge of two feet two inches; the mine-cars weigh 380 pounds, and hold 1,050 pounds of coal. This car or wagon is of a very convenient size, being easily handled. With a double track for nearly a mile underground, there is no difficulty in bringing out of this drift 1,000 tons per day. With a single track and sidings, not much more than half that amount could be carried.

In another drift the road is two feet nine inch gauge, in order to run mine-locomotives and to test the economy of their use as compared with mule-power. The mine-cars here weigh 580 pounds, with capacity for holding 1,500 pounds of coal. The proportion of dead weight to the coal carried increases with the width of track. Mr. James Herron, the manager of these mines, says, as the result of his observation and experience in mining operations, that, for coal-seams of nearly 5 feet, such as those at Fall Brook, a tram-road of two feet four inches gauge, with a mine-wagon of the capacity of 1,200 or 1,300 pounds of coal, with flange-wheels and a T-rail, would secure all the advantages obtainable in economy and convenience for hauling of coal from the mines to the shutes.

Two mine-locomotives were used in one of the drifts at Fall Brook, but their use inside of the mines has been discontinued, and that of mules substituted. The experience here was, that where up-grades occurred in the mines, or a large business is to be done, requiring much steam, the difficulties endured by the engineer and brakeman from the smoke, steam, and especially the carbonic acid produced by the engine in a confined place, like the gangways in coal-mines, become intolerable. Counting also the wear and tear and incidental expenses, it was found that more coal could be brought out of the mines in the same time by mules and fully as cheap. Where, however, the road is nearly level, and the slight grades that exist are in favor of the loaded mine-wagons, and no brakemen are required, mine-locomotives can be used with satisfaction and economy, and when tram-roads of considerable length are required out of the mines they answer a good purpose, or in lofty gangways in the large anthracite coal-beds.

The number of miners, laborers, mechanics, etc., directly employed in mining coal and in labor connected therewith at the mines, in producing 250,000 tons of coal per annum, which is the present production at Fall Brook, preparing it for market and putting the same in railroad-cars, is about 450, and the number of persons, men, women, and children, directly supported by the production of that amount of coal, will reach 1,800.

The Fall Brook Coal Company was founded by the late John Magee, formerly of Bath, N. Y., afterward of Watkins, N. Y., and the property is now exclusively owned by his heirs. A portion of the railroad by which the coal is carried to Watkins belongs to this company, together with locomotives, cars, extensive shipping-docks on Seneca Lake, canal-boats, and other property connected with the transportation of the coal. They also own the mines at Antrim, and the railroad from Corning to them. General Geo. J. Magee is the president, and John Lang treasurer. The company's office is at Watkins, N. Y.

Morris Run Mines and Village.—These mines are near the centre of the township of Hamilton, recently erected, which comprises the easterly part of the old township of Bloss. The tract of land pertaining to these mines contains about

7,000 acres, occupying the whole width north and south, and about three miles in length of the Blossburg coal-field. The village is located in the valley of Morris Run, which has been cut down through the coal-measures by the waters of the creek, thus affording an easy entrance to the coal and drainage for the mines. This village contains 347 dwellings, three school-houses, a store, office, hotel, market, saw-mill, town-hall, and forty-four other buildings, together with three churches, namely, Congregational, Methodist, and Baptist, having a population of 2,250, and, excepting only the churches, is owned wholly by "*The Morris Run Coal Company.*" These improvements have cost, independent of mines and movable fixtures, about $500,000.

The principal seam of coal, B, or the Bloss vein, is of varying thickness, not exceeding five feet. At the lowest part of the basin it lies nearly level, rising with an increasing ascent toward the outcrop, both to the north and the south. The greatest dip thus far observed is one in six—equal to an angle of nearly *ten degrees*, but usually the dip is much less. The floor of the mines is of hard fire-clay, slightly undulating. There is no explosive gas in these or in any other mines in this region, and so perfect is the ventilation that during the past eight years there has been no delay nor loss of time on that account. The roof is almost invariably good; props are set in rows about 4½ feet apart each way. The system of mining is known as the "post and stall," the gangways are made nine feet wide for a single track, affording room at the sides for men and mules to pass the cars. The parallel gangways are 400 feet apart, and, between these, chambers are worked transversely, 96 feet wide and separated by pillars 45 feet in width. Pillars 30 feet wide are left on both sides along the gangways. The overlying strata are from 50 to 250 feet in depth, and, as the pillars sustain the weight without crushing, the roof being good, the entire deposit of coal is taken out with no more waste than would occur in moving coal from a pile in a coal-yard.

The average miner, working alone, mines 4½ tons per day, and, assisted by a boy, he mines 6½ tons. Nearly all of the coal is level free, or above the natural drainage. The headings

and gangways are driven on the line of, or at right angles with, a slip, or natural vertical parting in the coal; and with so much regularity does the miner follow this guide, that his work is found to admit of straight lines, run by the transit, of 3,000 feet in length. The slip is a thin, vertical cavity in the coal, usually filled with a fine atomic substance resembling pulverized charcoal, and its magnetic course is south 12° east.

The tracks in the mines are T-rail, weighing 16 pounds to the yard, and of 30 inches' gauge. One of the mines of this company was formerly worked by the Tioga Improvement Company, under the management of Alfred Jones. Three mines are now worked, called the East, the Tioga, and the Jones mines, and together they have a capacity of 2,500 tons per day. The largest mine, having a double-track entry, yielded 40,388 tons in one month from one drift, and at about that rate for several months, working 26 days, eight hours per day. The largest production in one day of eight hours was 1,850 tons. This exceeds the capacity of any anthracite mine.

In the year 1870 a small locomotive was introduced to take the place of mules in hauling the coal from the mines. It weighs five tons, runs on a track of 30-inch gauge, and is equal to 12 mules. It works well on outside roads, but, unless some plan shall be devised to prevent the escape of smoke, it is doubtful whether the locomotive can be used to advantage inside the mines. The experiments here seemed to show that it is not suitable for inside hauling.

During the winter months but little coal is sent to market; the production is continued at a moderate rate, and from 50,000 to 100,000 tons put on the stock-ground at the mines. One hundred thousand tons of coal in one pile is a sight worth seeing. The coal thus stocked is shipped during the summer when needed, to keep the movement regular, on occasions of accidents, holidays, etc. A *steam-shovel* is employed in the stock-coal, capable of loading 100 tons per hour into the cars. Three men are employed on this machine, and the expense of moving the coal is reduced to less than one-half that of hand-labor. It cost $4,700, and in form it resembles an ordinary dredging-machine or steam-excavator, mounted on a railroad-track.

Eight hundred men are employed in the mining operations

at this place, and they with their families, numbering 2,250, are wholly supported by this business. These men earn annually $430,000, nearly all of which is expended in this county for the various necessaries of life and for land. There is a brisk demand for all agricultural products, and the whole of Tioga County is greatly benefited by this mining business.

The production and shipment of coal from the mines of the Morris Run Coal Company in 1871 were 385,996 tons, and the total since the opening of the mines by the former owners in 1853 is 2,842,263 tons, of which 1,331,269 were used for manufacturing salt at Syracuse, N. Y. The company is exclusively a coal mining and selling company, their railroad transportation being furnished by the Blossburg Coal Company, who own the Tioga Railroad; but they have a fine shipping-dock at Coal Point, near Watkins, N. Y. The stock of the Morris Run Coal Company is held chiefly by James P. Haskin, of Syracuse, N. Y., where the company keep their office. The only other stockholders are William T. Hamilton and wife. Mr. Hamilton is the secretary and the executive officer of the company. W. S. Nearing is the manager of all the company's operations in the production of the coal and other business at Morris Run. Hon. T. T. Davis, late of Syracuse, deceased, and his son, Major Alexander H. Davis, formerly had a large interest in the stock of this very successful company.

Mines of the Blossburg Coal Company, and their Village called Arnot.

This company commenced work in 1866, when they established their mines and mining town at a point in the then wilderness country about four miles westerly from the village of Blossburg, without even a common wagon-road by which to approach the place of their operations. In a short space of time, with almost unparalleled energy, they built not only wagon-roads but also a substantial railroad connecting their mines with the Tioga Railroad at Blossburg. Where a dense wilderness existed in 1866, now may be seen a village containing 280 good, substantial tenement-houses, and about 2,200 inhabitants, an extensive steam saw-mill and general lumbering establishment, a large store, storehouses, barns, coal-shutes,

WORKING PLAN OF THE MINES OF THE BLOSSBURG COAL COMPANY.
AT ARNOT.

Fig. 30.

B= A

Scale 400 feet per inch. A is the main gangway. B is the return air-course and ventilating shaft. The shaded portions represent the ground already worked over, and the white the unmined coal. For description of the system of mining, see pages 99, 100—also 139, 140.

and other improvements necessary to successful operations in mining and producing coal, all the property of this company, and occupied by their miners and other employés. F. N. Drake, Esq., of Corning, N. Y., is the president of this company, and to his sagacity, energy, and business capacity, they are largely indebted for the success that has attended the enterprise in which they are engaged.

The production of coal at their mines, in 1871, amounted to about 220,000 tons, and will doubtless be increased to 300,000 tons in the year 1872. They employ regularly about 700 men in mining and outside labor, including their lumbering business, and use in connection with their mining operations about 60 mules, 700 mine-wagons, and one small locomotive. This locomotive is used exclusively in hauling the coal from the entrance into the drifts to the shutes on the railroad, where it is transferred through pockets into cars and made ready for transportation to market. According to the report of James Cameron, the mining superintendent, this small locomotive performs the labor of at least 14 mules, quite as expeditiously and satisfactorily, and at a largely reduced expense. The tram-road on which it is used is of two feet and six inches gauge. T-rails are used, weighing 25 pounds to the yard, and mine-wagons carrying about 1,500 pounds each. This company owns about 20,000 acres of land, or about 31 square miles of territory, and, situated as it is in the coal-basin, it is believed to be mostly underlaid with coal. Two seams are now being worked, one about 150 feet above the other, producing from 1,000 to 1,400 tons daily. The coal-seams occur in a very regular position, with sufficient dip for good drainage, without being too steep for easy transportation of the coal. The gangways, by which are meant the principal roads extending through the mines; the headings, by which are meant the roads running through the mines at right angles with the gangways, sometimes called the parallel headings; and the breasts or wide apartments, in which the principal part of the coal is mined, opening out from the headings, are all laid off at right angles as regularly as the streets of the city of Philadelphia. But the plan of the mines presents this important difference, that all these gangways and headings are double. Here is a

great item of expense which the visitor or casual observer sees but little of, being, like many other expensive improvements necessary in operating coal-mines, seen and appreciated only by those who make a more thorough inspection. The object of these double gangways was shown in describing the method of furnishing the mines with fresh and pure air,[1] to accomplish which this company have spared neither pains nor expense, and as a consequence their mines are well ventilated.

This company own the railroad branches from Blossburg to Morris Run and to Arnot, and that over which their coal as well as that produced by the Fall Brook and Morris Run Companies is transported, extending northerly from Blossburg to the State line, a distance of 26 miles, and in all 34 miles. At Lawrenceville it connects with the Blossburg & Corning Railroad, operated by the Fall Brook Coal Company, and extending from the State line aforesaid to Corning, a distance of about 15 miles, and over which the productions of the other two companies mentioned are also transported. From 150,000 to 250,000 tons of the production of the Blossburg Coal Company are furnished annually by them to the Erie Railway Company for fuel for their locomotives, etc. A large portion of the balance is transported to Watkins, where they have extensive transfer-works for reshipping coal from cars to boats on the Seneca Lake. All three of these collieries and mining villages present the same general features, and portions of the descriptions of each apply to them all. The improvements made by the three companies are all of a substantial and durable character, and all their operations are on a liberal scale. The mining-work has the important advantage, that it is continued without interruption during the whole year, and with very little fluctuation in the rates of wages or the demand for labor. The companies all have sufficient capital, and pay all their employés promptly in money as soon after the close of each month as their accounts can be settled. The coal is sold at a very low price, but at very uniform prices throughout the year, and from year to year. As it is used for locomotive and other steam purposes, for rolling-mills and other manufacturing uses, it is not subject to the fluctuations in the demand to which the trade in anthra-

[1] See page 99, and cut on page 145.

cite for domestic use is liable. The demand has for some years been steadily increasing, and there has been no excessive production. While these coal companies have been wise enough to be satisfied with a small profit on each ton, and have thus very much increased the market, they have been prudent enough not to be induced by competition to sell any part of their production at less than its cost.

ANTRIM.

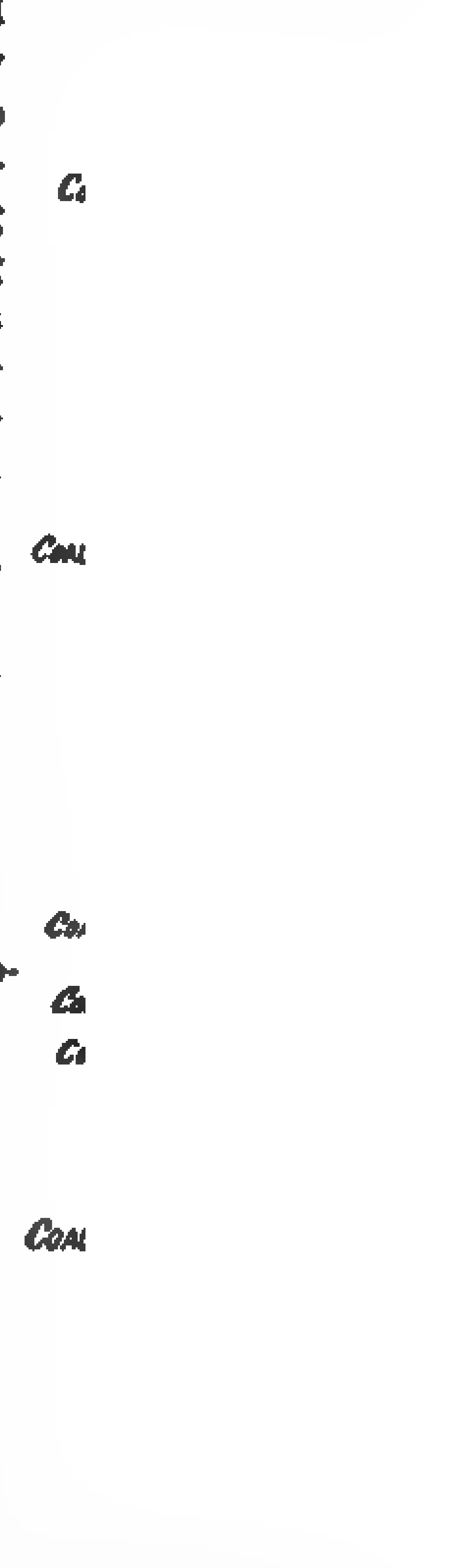
At the mines and mining villages already described, the works are completed, and in full working order. More dwelling-houses for miners may hereafter be erected as may be necessary, in order to increase the production of coal, but, in other respects, little change takes place, except the enlargement from year to year of the underground operations.

At Antrim, on the contrary, the visitor during the summer of 1872 could have seen the commencement of a new colliery, and, if he had the time to spend, he might have witnessed every successive step from the first exploration of the land for the discovery of the coal-seams down to the shipment of the first coal to market.

The Fall Brook Coal Company having determined to develop the coal on their lands situated south of Wellsboro, and west of Arnot, have lately built a railroad 38 miles in length, from Lawrenceville, at the New York State line, to Antrim, by way of Wellsboro. It is now completed and in running order to the latter place, and the remainder of the road will be finished before these pages reach the reader. This new railroad connects, at Lawrenceville, with 15 miles of road belonging to the same company, called the Corning & Blossburg Railroad (*see* map on page 125). The Fall Brook Coal Company thus will have a complete line of road from the Erie Railway at Corning to Antrim, 53 miles in length. They also own the six miles of road from Blossburg to Fall Brook. Although the road to Wellsboro passes through the older settled portions of Tioga County, and that pleasant and thriving village, yet the principal object in its construction was as an outlet to market for the coal from Antrim. The mountains of Northern Pennsylvania are covered with a dense forest of large hemlock-trees, extending

for many miles without intervals of cleared land. Those who settled in this country as farmers, preferred the valleys situated lower down than the coal-rocks. About eight miles of the route of the railroad next to Antrim is through the forest referred to, the location of the mines being between Wilson's Creek and Babb's Creek. Here in this lately silent wilderness, hundreds of men are busily at work building railroads, coal-shutes, and other fixtures, opening mines, building tram-roads, erecting numerous dwellings for miners and other employés, stores and store-houses, and arranging for the permanent and comfortable accommodation of a population of some 2,000 people, and for the mining and sending to market of a large quantity of coal. This will be simply another Fall Brook village with similar mines, in the same third coal-basin, in the same Blossburg seam, and producing the same bituminous coal belonging to the same coal company.

FIG. 31.



Section of the Coal Strata at Antrim. Scale 80 feet to 1 inch.

The Antrim mines, as will be noticed on the map on page 125, are situated near the common corner of Charleston, Morris and Delmar townships. Here the Fall Brook Coal Company own a large body of coal-lands as well as at Fall Brook, together amounting to 25,000 acres. The whole area, in addition to its mineral wealth, is covered with a noble forest of hemlock and hard-wood timber of an excellent quality.

The annexed geological section, furnished by the company's engineer, Mr. A. Hardt, shows two coal-seams of an excellent workable

thickness, separated by 64½ feet of intermediate strata. The railroad will be completed and ready to ship coal from Antrim in January, 1873. These mines will prove a source of wealth and prosperity to the people of Tioga County, in addition to the great convenience of having a railroad connection from the heart of the county to the outside world.

But the quality of the coal produced in the Blossburg region, the true and substantial basis of the business, remains to be considered.

Semi-bituminous Coal.

In view of the large tonnage in this species of coal, and the fact that there is less known in regard to its qualities and peculiarities than other coals, a further account of the latter will now be given, which will also apply to all the semi-bituminous coals from the other regions, particularly those from the McIntyre and Towanda districts.

On taking a general view of the field of semi-bituminous coal, we see, along the eastern part of the Alleghany range of mountains, a region which produces an entirely different kind of coal from the anthracite, and different from the common bituminous coal, possessing peculiar and very valuable properties. This kind of coal is not found outside of the region mentioned, and the changes which are seen in all coals elsewhere east and west of it show that this is the only part of the country in which semi-bituminous coal may be expected to be found. These coals are known in the markets where they are sold by the names of Blossburg, Clearfield, Broad-Top, and Cumberland coals. The first is produced in Tioga County, Pennsylvania, near the village of Blossburg, 30 miles south of the south line of New York. The Barclay or Towanda region is situated in the adjoining county of Bradford, east of the Blossburg, at the same distance from the State line, and is farther east than any other coal except the anthracite. The McIntyre or Ralston field is midway between the other two just mentioned, and in the northern part of Lycoming County. Broad-Top coal is found on the line between Huntingdon and Bedford Counties, in the southern part of Pennsylvania, and the Cumberland region is in the western part of Maryland. A line drawn on the map

of Pennsylvania and Maryland through the Blossburg region in a southwestern course would pass through or near the Broad-Top and Cumberland, as well as two other intermediate semi-bituminous coal-regions at Snowshoe and Phillipsburg, in Centre County, Pennsylvania, all of which produce the same species of coal. The production of the semi-bituminous regions in Pennsylvania in 1871 was as follows:

	Tons.
1. Blossburg, 8 coal companies	815,079
2. McIntyre, 1 " "	106,130
3. Towanda, 2 " "	378,335
4. Snowshoe, 1 " "	82,468
5. Phillipsburg, 16 " "	542,896
6. Johnstown or Cambria Iron works, 1 company	263,472
7. Cambria County on Penn. Railroad, 10 companies	206,792
8. Broad-Top, 19 companies	319,618
Total	2,714,790

These regions produce what may emphatically be called the manufacturing and steam-making coal from which our country derives important elements of its greatness as a producer from the raw material of whatever is used by man, as well as, to some extent, its commercial and national prosperity. This coal is therefore worthy of a special account, as well as for the importance it has attained in the market, and the probable future magnitude of the trade.

"The term *bituminous coal* is somewhat deceptive, and it must be remarked that it does not mean that any bitumen or mineral pitch soluble in ether is contained in it, but that the gases, oxygen, hydrogen, and nitrogen enter more largely into its composition than in anthracite, and give it a more flaming character in burning." It burns like bitumen, but it is doubtful if any coals contain bitumen in the ready-formed condition.

Semi-bituminous coal, in the sense in which we shall use the term to distinguish it from common bituminous coal, is that peculiar kind produced in the regions mentioned, which, while it yields coke and combustible gases, yet contains only 11 or 12, and always less than 18 per cent. of volatile combustible matter, and not less than about 70 per cent., and never more than 84 per cent., of carbon.

Whatever may be its useful qualities, it must be confessed it is in mere appearance inferior looking to almost any other kind of coal. As it comes from the mine, or, in technical phrase, "the run of the mines," it consists of at least from one-third to one-half of fine coal, or what English miners call "dead small," and some of it may be called dust. The large or lump-coal is black, shining, and much more easily broken than anthracite, falling into irregular-sided cubical pieces, the cleavage being very much the same in a cross-fracture as in the plane of stratification. It seldom cleaves into smooth, perfect cubical blocks of any size like the Pittsburg coal It is decidedly dirty, cannot be touched without soiling the hands, and its whole merit and value consist in its useful qualities.

All other kinds of coal must concede to anthracite, as has been said, the market for household use, on account of its superior cleanness and freedom from smoke, soot, and flame. Anthracite and the harder species of laminated splint coal, from their hardness, alone can sustain the weight of a charge in a blast-furnace for making pig-iron. Lehigh and other very hard anthracites are preferred for melting pig-iron for foundery purposes. The true bituminous coals from the western part of the Alleghany coal-field in Western Pennsylvania and Ohio are justly entitled to the market for manufacturing gas. But there is no other purpose except the above for which semi-bituminous coal in its raw state is not well adapted. It has a wider range in its use than any other kind of coal. For blacksmithing, for puddling, and heating in rolling-mills, and for steam, all kinds of coal are used, just as all sorts, however unsuitable or inferior, are to some extent used for household purposes; but the kind of coal which is invariably admitted to be by far the best adapted for the work of the blacksmith or ironsmith (as he should properly be called) is what we are describing as the semi-bituminous coal. This is mainly owing to its great heating power, and its making what is called in the language of the trade "a good hollow fire." The fine portions of the coal, which are generally used alone in this work, become adhesive and cemented together in burning into a compact body on the outside; the fire being confined to the interior of the mass, the coal not burning outwardly, but only around the iron which

the smith is heating, and forming an arch lined with burning coals, into which the iron is thrust, while the outside presents no appearance of fire. This is not only a more economical fire, burning the coal only where it is needed, and protecting the workman from the heat of an outside blazing fire, which is so objectionable, particularly in hot weather, but it makes a hotter fire by concentrating the heat in the interior directly in contact with the iron where it is needed.

In addition to this, these semi-bituminous coals possess the very valuable quality so indispensable for this work, and so important in all uses, in being free from sulphur. The great importance of this is but little appreciated in the Eastern States. As so much of the coal produced throughout the great Alleghany coal-region is of a good quality, we are only enabled properly to estimate its real excellence and its great purity after witnessing the masses of sulphate of iron brought out of the mines with the coal, and much of it adhering to it and sold as coal, in the States of Michigan, Illinois, and Missouri. For smithing, or for any work connected with the manufacture or use of iron, nothing is more injurious. In the New York, Philadelphia, Baltimore, Boston, and other Atlantic markets, no other coal is sold or used for blacksmithing but Cumberland, Clearfield, and Broad Top; while in the interior of the State of New York, in Western Canada, or Ontario, and in all the Western or Northwestern States, every blacksmith uses Blossburg coal, which is the generic name by which all this kind of coal from Northern Pennsylvania is called. As an instance of the distance to which this valuable fuel is carried, it may be stated that 75,053 tons were shipped in 1871 from Oswego and Buffalo to Canada and our own Western States. Chicago alone took 21,248 tons before the great fire, and had an insufficient supply, much of which was resold and shipped off by railroad westward and northwestward. Some of it was resold as far as Omaha, and shipped still farther westward hundreds of miles toward the setting sun. The blacksmiths of Salt Lake City, in Utah, use Blossburg coal, and it is even carried in sacks over the plains and over the mountains through the gold-regions of our far Western Territories, to sharpen the tools of the miner several thousand miles from Blossburg, where

it was mined. This is owing, not to the absolute want of other coal, but to the Western coal not possessing those peculiar qualities before described required for this business.

What has been said in regard to blacksmithing applies to puddling, heating, and rolling-mills. This work, however, is not done by a hollow fire, but by the passing over the iron of the heat and flame of the coal, requiring a strong coal with great heating power, burning with a flame so as to diffuse the heat from the furnace where it is burnt over the iron placed in the line of the draught, requiring also a coal free from sulphur and other impurities. All the puddling and heating furnaces from Troy, New York, to Buffalo, use Blossburg coal in very large quantities, as by the statistics of the trade for 1871 herein presented will appear. *See* page 159.

There is also this important and useful attribute of this species of coal which is not often referred to, but which is a high recommendation for its use in blacksmithing, in puddling, and heating in rolling-mills, and in generating steam under boilers, giving it an advantage over anthracite: "The hydrogen of the gaseous part of the coal is a potent purifier or remover of any sulphur with which either the coal itself or the iron may be contaminated. The excellence of the iron of the bituminous black band of Scotland is admitted to be due to the purifying influence of the hydrogen of its bitumen."—(*Rogers.*) The superior quality of the wrought-iron puddled and heated with semi-bituminous coal is well known; the reason being that the anthracite, unlike the semi-bituminous coal, contains but little hydrogen to form a chemical combination with, and carry off the sulphur. The Ohio geologists have proved, in the course of the present survey, that where the sulphur in coal is not combined with iron but with the volatile portion of the coal, it passes off in coking, or in ordinary combustion.

But the largest demand for Blossburg and other semi-bituminous coal is for the *generating of steam* in locomotive and stationary boilers. The qualities required for a good steam-coal are various, and are not very well understood. The value of coal for this purpose of course depends mainly upon its heating power, and it has been often said, very unphilosophically, that this depends on the proportion of carbon it contains. It is pro-

posed to add to this volume a chapter on the combustion of coal, and at present it is sufficient to say that combustion is the chemical union of the combustible material with oxygen, and that the hydrogen in Blossburg coal theoretically is capable of uniting with three times as much oxygen as so much carbon could have done. It therefore gives the coal more heating power than if the coal were all composed of carbon. Carbon, however, is the most useful constituent of coal, because the most available.

"The question of the value of coals for the purpose of generating steam is, of course, mainly dependent on their heating power; that is, on the weight of water which a given weight of coal, burned under a given evaporating vessel, can convert into steam while undergoing combustion. But this is not the only circumstance requiring investigation, in order to decide their value.

"The manner in which it burns, whether with much or little flame; the amount and character of its combustible ingredients; its facility or difficulty of ignition; the perfection of the combustion, or the proportion of the whole amount consumed to that of the combustible matter placed upon the grate; the concentration or diffusibility of its heat; the proportion of humidity and that of the sulphur which it may contain, with the consequent liability, under certain circumstances, to undergo spontaneous combustion—are all points requiring attentive consideration. In addition to these, we have the question of the manner in which each coal behaves when coming to the temperature of ignition; its tendency to retain its original form; the nature and extent of change when any occurs, whether by simply cracking and disintegrating into angular fragments, or by enlarging the bulk, rounding away and obliterating the angles, and yet not agglutinating mass to mass; or, finally, by wholly changing its form and consistence, swelling to a great degree, and cohering so as to form a nearly continuous roof, and thus impeding the passage of air through the ignited coal. In some cases the question of the amount of solid matter which accompanies the gaseous products of combustion in the state of smoke, becoming soot upon the flues of the apparatus in which the combustion is conducted, is one of great practical importance. Of these incidental questions the amount and character of the incombustible ingredients of different coals is a point

eminently deserving of notice. It indicates the deduction which must, in all cases, be made from the heating power of an equal weight of the coal, considered as pure combustible matter; it shows the extent and kind of labor requisite in managing the furnace; it warns us what to expect in regard to the durability of grate-bars, and the adhesion of scoriæ to those important appendages of the furnace. All these subjects must necessarily engage the attention of engineers and furnace-managers, and no little portion of the good or bad character in coal may be considered to depend on these circumstances. The relation of the incombustible ingredients of coal to each other is often such as to render the mixture fusible at the temperature of ordinary furnaces, or at least to be in a certain proportion reduced to a pasty, coherent mass upon the grate, impeding the passage of air, leaving another portion unvitrified, and capable of passing through the interstices between the bars. For different coals this proportion is very different, even when the combustion is conducted as far as practicable in the same manner and with the same intensity of heat."—(*Walter R. Johnson.*)

The tendency of semi-bituminous coal to melt and cohere so as to form a crust and in part impede the passage of air through the coal, might at first view be considered as an objection to its use for steam purposes. But in the chapter on the combustion of coal it will be shown that, for the proper utilizing of the hydrogen gas given out in burning, a very large quantity of atmospheric air is required, so large that very few furnaces afford a sufficient supply to produce perfect combustion. Now, in burning bituminous coal which has not this melting or caking quality the hydrogen gas is given out so rapidly, the coal burning altogether outwardly, that for the want of sufficient oxygen much of it passes off unconsumed, and a large part of the heating power of the coal is lost, whereas with the semi-bituminous or caking coal the gas is partially retained by the formation of the crust, and is given out more gradually, the crust acting the part of a temporary gas-holder, from which the fireman with his poker can, as occasion requires, by breaking the crust, allow the gas to escape in such quantities that it may unite with the limited supply of oxygen. This caking quality is very valuable in a locomotive coal, where the draft is so strong

that an adhesive coal is preferred, and it admits of the use of grate-bars with wider air-spaces than can be used with other coal that would be liable to fall through the grates, which is attended with a loss of fuel.

"The superintendent of the United States Armory at Springfield, Massachusetts, has recently been conducting a series of experiments to test the value of certain kinds of coal as steam-generators. Each variety of three different classes of coal was used for six consecutive days in raising the steam for the engine of the establishment, with the following reported results: Of the Lackawanna, or hard anthracite, 4.01 pounds per horse-power were used per hour; of the Pittston, a softer anthracite, 4.02 pounds were used; and of the Cumberland, or bituminous coal of Maryland, 3.03 pounds were used. At the Springfield Armory, the Lackawanna coal cost $8.50 per gross ton, the Pittston $7.85, and the Cumberland $9.10. From these data it is calculated that the cost, per horse-power, is 15 mills for Lackawanna, 14 mills for Pittston, and 12 mills for Cumberland; and it is therefore alleged that bituminous coal is the more economical fuel as a steam-generator, making more heat and creating more power per pound and per cent. of cost than the harder coals.

"This has also been done at Colt's Armory in Hartford; and after careful experiments it was found that for steam-generating purposes the Cumberland coal was better and cheaper than the anthracite, whether compared ton for ton or by the relative cost of the two."

And Prof. J. P. Lesley, in the *United States Railroad & Mining Register*, adds: "This result was established years ago by the experiments conducted by Walter R. Johnson under orders of the United States Government, and has been re-established by the practical working of the coals used by the ocean-steamers."

Prof. Johnson conducted experiments on 41 different varieties of coal, both anthracite and bituminous, and among others with Blossburg coal. By his report, published by Congress in 1844, it appears that "the rate of evaporation of water per hour by Blossburg coal was scarcely exceeded by any coal tried during the course of these experiments," and in the

table of the names of the coals in the order of maximum rapidity of evaporation Blossburg is second on the list of 41 varieties, being above all the Cumberland and anthracite coals, as it is also in the table showing the order of the coals in respect to rapidity of ignition. Rapidity of ignition and in evaporation are very important qualities in a steam-coal, especially in a locomotive, or other engine where time is of great importance. In the order of the evaporative power with equal weight and equal bulk of coal, and in the various other aspects in which comparisons were made, Blossburg takes a high rank equal or above most varieties of both Cumberland and anthracite.

In this report, Prof. Johnson first pointed out the resemblance between the coke formed in the combustion of bituminous coal and the lungs of animals. Respiration is a process exactly analogous to that of combustion, both being the chemical union of the particles of carbon or hydrogen with particles of oxygen. These do not unite readily but by atoms, and must be brought together in as many small jets as possible. Nothing in nature is so admirably fitted to expose large surfaces for the rapid absorption of oxygen as the lungs; and the superior rapidity of combustion and heating power of a coal-forming coke is the known fact of its porous texture and the admission of numerous small particles of air to a vast extent of surface for combustion. But with respect to anthracites, on the contrary, it may be said that their combustion is effected solely by the contact of the air with the surfaces of their solid masses.

The following is a summary of the total joint production of coal from the Blossburg, McIntyre, and Towanda coal-regions for 1870 and 1871, with a statement of the uses made of the coal in the latter year:

COAL REGIONS.		1871.	1870.	Increase.
Blossburg region.	3 companies	815,079	733,035	82,044
McIntyre "	1 company	106,130	17,808	88,322
Towanda "	2 companies	378,335	273,335	105,000
Total tons		1,299,544	1,024,178	275,366

The coal produced in 1871 was used as follows:

For locomotive purposes by the Erie Railway; the New York Central & Hudson River Railroad; the Rensselaer & Saratoga Railroad; the Rome & Watertown Railroad, and other smaller railroads in New York	619,054
By rolling-mills at Troy, Rome, Syracuse, Buffalo, Elmira, and other places	242,211
By the Onondaga Salt Company, at Syracuse	170,142
Used for stationary engines, steamboats, and sold to coal-dealers	168,285
Used for blacksmithing	99,852
Total as above	1,299,544

The total production of these three districts since the mines were opened is 6,453,222 tons, of which 5,881,750 tons were from the Blossburg region proper.

It will be noticed that, by the foregoing statement, 50 per cent. of all the semi-bituminous coal mined in Northern Pennsylvania is burnt on railroads, in locomotive-engines. The qualities to which it is indebted for this very important market are, among others, that it burns so that steam may be raised in a very short period, and maintained at the proper pressure which is often highly necessary. To "make time" is the railroad-engineer's first duty, the great aim of his life, and he therefore requires a coal that is able to produce a quick action. In W. R. Johnson's experiments, made for the Navy Department, Blossburg coal is equal to any of the coals used in this respect. It also possesses high evaporative power, is capable of converting a large amount of water into steam with a small consumption of coal, and is attended with very little smoke, soot, or cinders. Semi-bituminous coal contains but a small portion of matter to be vaporized, and therefore soon comes to a temperature of full ignition. The considerable increase of volume which it takes in coking favors the consequent rapid and effective combustion of the fixed carbon. In some cases, especially when brought very gradually to ignition, the masses of coke scarcely cohere, and the original forms of the lumps are in a measure preserved. It is also free from any considerable quantity of sulphur.

The only analyses known to have been made of coal from any of the mines now in operation near Blossburg, are the following, by Dr. Goessman. To these is added that made by W. R. Johnson, of coal from the old Blossburg mines, which were situated directly at the village of that name. The coal

now produced is of a much better quality. No coal has been sent to market from that mine since the year 1858.

	DR. GOESSMAN, 1856.			W. R. JOHNSON, 1844.
	East Mine.	Jones's Mine.	Tioga Mine.	Old Blossburg Mine.
Fixed carbon.........	76.075	77.655	77.935	75.108
Volatile matter........	15.350	13.795	12.505	13.927
Earthy matter........	8.575	8.550	9.560	10.778
	100.	100.	100.	100.

Results of United States Government Experiments in Burning Coal under a Steam Boiler.

ANTHRACITES.	Analyses.				Efficiency. Hours to bring boiler to steady action.	Cubic feet water evaporated per hour during steady action.	Pounds steam to one pound coal from initial temperature.	Pounds of steam to one pound of coal from 212°.	Steam from 212° from one pound combustible matter.
Beaver Meadow Anthracite.......	1.610	2.28	88.94	7.11	3.57	12.57	8.90	9.21	10.466
Beaver Meadow Anthracite.......	1.557	2.66	91.47	5.15	2.42	10.66	8.76	9.88	10.592
Forest Improvement Anthracite...	1.477	3.07	90.75	4.41	3.92	12.59	8.92	10.06	10.807
Peach Mountain.................	1.464	2.96	89.02	6.19	3.54	14.04	8.96	10.11	10.871
Lehigh........................	1.590	5.28	89.15	5.56	3.27	11.63	7.73	8.98	9.626
Lackawanna....................	1.421	3.91	87.74	6.35	2.67	11.92	8.56	9.79	10.764
Lykens Valley..................	1.389	6.38	88.24	9.25	2.63	12.89	8.43	9.46	10.738
Beaver Meadow..............	....	....	....	8.10	5.08	9.42	7.58	9.08	9.881
Average................	1.501	3.877	88.70	6.51	3.25	10.67	8.42	7.07	10.478
SEMI-BITUMINOUS.									
New York & Maryland Mining Co..	1.431	12.31	73.50	12.40	1.86	12.79	8.65	9.78	11.208
Neff's Cumberland	1.337	12.67	74.68	10.34	1.68	14.60	8.19	9.44	10.604
Easby's Coal, Maryland...........	1.307	14.98	76.20	8.06	1.75	13.78	8.88	10.02	10.985
Atkinson & Templeman's..........	1.318	15.58	76.69	7.83	0.99	15.70	9.47	10.70	11.624
Early's & Smith's	1.333	15.52	74.29	9.80	1.52	14.97	8.69	9.96	11.084
Cumberland Navy Yard...........	1.414	14.37	70.85	14.36	....	....	....	....	..
Dauphin & Susquehanna..........	1.443	13.82	74.94	11.49	0.83	13.35	8.31	9.34	11.171
Blossburg....	1.324	14.78	78.11	10.77	0.84	15.67	8.64	9.72	10.956
Lycoming Creek..................	1.335	13.84	71.58	13.96	1.72	12.18	7.92	8.91	10.724
Quin's Run.......................	1.331	17.97	73.79	8.41	0.75	13.90	9.08	10.27	11.275
Average................	1.308	14.69	73.78	10.70	1.26	14.00	8.58	9.68	11.069
BITUMINOUS.									
Karthaus, Pa....................	1.264	19.53	73.77	7.00	1.87	12.43	7.92	9.09	9.987
Cambria County, Pa..............	[illegible]	20.52	69.87	9.15	2.00	12.47	8.04	9.24	10.220
Pictou, Nova Scotia..............	[illegible]	27.33	56.98	13.89	0.94	12.79	7.42	8.41	9.716
Sidney, Nova Scotia..............	[illegible]	28.81	67.57	5.49	1.18	13.85	7.01	7.99	8.497
Pictou (Cunard)	[illegible]	25.97	60.74	12.51	0.85	16.47	7.45	8.48	9.649
Liverpool, England	[illegible]	39.96	54.90	4.69	0.56	13.48	6.95	7.48	8.255
Newcastle, England..............	1.257	35.38	57.00	5.40	0.84	13.75	7.66	8.66	9.175
Scotch..........................	1.519	39.19	48.81	9.84	0.96	14.82	6.14	6.95	7.719
Pittsburg, Pa....................	1.252	36.76	54.93	7.07	....	10.56	7.08	8.20	8.942
Cannelton, Ind..................	1.278	38.99	58.44	4.97	0.50	15.05	6.81	7.84	7.784
Average................	1.2985	30.339	60.301	7.394	1.11	13.51	7.20	8.16	8.96

The foregoing general synoptical table of the analyses and efficiency of American coals is the result of Prof. W. R. Johnson's elaborate experiments, made at great expense for the United States Navy Department, in 1844. The Richmond (Virginia) coals are omitted in this table, as they have gone out of general use. They are arranged in three classes, as anthracite, semi-bituminous, and bituminous. It shows that coals of similar analysis, taken from regions widely separated, produce similar results. The semi-bituminous varieties are the best in respect to evaporative power per pound; and, in respect to their efficiency in a given time, they are far superior to both anthracite and bituminous coals. Of the ten varieties of semi-bituminous coal, Blossburg has exactly the average analysis of them all, and in efficiency it is above the average.

2. McINTYRE.

The Northern Central Railroad at Ralston, Pennsylvania, 24 miles north of Williamsport and 54 south of Elmira, is 808 feet above tide-water. It here runs at the base of two very steep mountains, which shut in the narrow little valley of Lycoming Creek. At both the east and west side appear the upper members of the red slate and red sandstone, called, in the Pennsylvania Reports, Formation IX., or Rogers's Ponent, but they are scarcely visible at Ralston, while, a few miles both above and below, they again come in, by a change of dip.[1] It is this curve in the strata which gives the trough-shape to the formation at this point, and causes such a depression along the central or synclinal line of the basin, that the coal-measures, the highest strata in Central or Western Pennsylvania, find their place below the summit of the hills. The next formation of rock, above the red shales and sandstones, is No. X., or Rogers's Vespertine, which is a series of hard gray sandstones. This rock generally constitutes the principal part of the eastern or southern slope of the main Alleghany ridge. It is in thin beds, seldom in large blocks, projecting in bold cliffs. The next formation is No. XI., or Rogers's Umbral, consisting of soft red shales, very nearly 100 feet thick in this part of the

[1] Reports of J. T. Hodge furnish the geology of this article.

State, and contains several beds of iron-ore. These three formations, IX., X., and XI., or Rogers's Ponent, Vespertine, and Umbral, are subdivisions of what, in Dana's "Manual," and other books on geology, are called the Catskill group.[1]

The next formation, XII., or Rogers's Seral Conglomerate and Sandstone, is the floor of the coal-measures, and at Ralston is only 70 to 80 feet thick, though in some other counties it exceeds 1,000 feet. It is a massive sandstone, composed of white quartz, pebbles, and sand. Being exceedingly hard and durable, it has withstood better than the other strata the wearing agencies that have given the present outlines to the hills, and is everywhere the most prominent rock, standing out in precipitous ledges, or capping the ragged summits around the margin of the coal-fields. It is so well marked, in its appearance and position, that it is the best guide to determine the presence of the coal-measures, the next formation above, as also to mark the position of the valuable bed of iron-ore which, in this region, is found immediately below the conglomerate.

The coal-measures occupy the summits along the line of the basin. They consist of sandstone, shales, fire-clay, beds of coal, and some iron-ore in the shales. It is only the lower part of the series that catches in these hills. The width of the basin does not appear to exceed six miles, and the length of the area occupied by the coal-formation, before it is interrupted by the conglomerate, is believed to be about ten miles. Both in length and width, however, there are occasional interruptions caused by the valleys. The lower any coal-seam is found in the hills, the more area it will cover, or the less it will have been cut up and removed by the process of excavation of the ravines and valleys.

Ralston is at the mouth of Stony and Rocky Run, on Lycoming Creek, and, like Barclay, is in the second coal-basin. The hills are about 1,000 feet high, surmounted by conglomeritic sandstone. The centre of the coal-basin crosses Lycoming Creek near the mouth of Dutchman's Run, where the McIntyre Coal Company's mines are situated, one mile above Rocky Run and Ralston station. The anticlinal axis, causing the southern margin of this basin, crosses near the mouth of Pleasant Stream, about four miles south of the McIntyre mines.

[1] *See* page 115 for Pennsylvania geological series.

while the other axis, bounding it on the north, passes near the mouth of Roaring Branch, about 2½ miles north of McIntyre.[1] The hills, including the coal-measures, occupy a range of country extending east to the end of Towanda or Barclay Mountain, at Greenwood, and west nearly ten miles in length; but the coal is not continuous over all this extent, being interrupted by deep valleys of denudation. The principal localities of the coal at Ralston are on the east side of the creek, on a branch of Rocky Run, between that stream and Dutchman's Run, where are situated the new coal-works of the McIntyre Coal Company, erected in 1870; also on Red Run, on the west side of Lycoming Creek and Valley; and on Frozen Run, near Astonville. The height of the coal above the creek at Ralston is about 875 feet. On the road leading to the old mines, and below the conglomerate, in a bed of dark shale, there is a valuable band of iron-ore, lying only four feet beneath the rock, from which it is separated by a layer of brown shale. The conglomerate and sandstone stratum, below the coal, varies from 45 to 150 feet in thickness. The top of this rock is marked by a terrace, gently receding from the front of the hill to an abrupt slope, formed by a bed of white sandstone, about 60 feet in thickness. Between these two sandstone beds we find a seam (1 or A) of rather slaty coal, from 18 to 30 inches thick, underlaid by 30 inches of slate. Over the sandstone occurs another bed of coal (2 or B), six feet thick, but not of superior quality, the lower part of it consisting of slaty cannel coal, and the rest being rather hard. It includes two bands of slate, one eight inches, the other, near the bottom, three inches thick.

Another coal-seam (3 or C), between two feet six inches and two feet ten inches thick, occurs seven and a half feet above the former. It contains three inches of slate near the middle, but supplies an excellent coal for coking, and is much superior to the thicker seam beneath it. Above this coal we find a bed of shale, containing large nodular balls of iron-ore, the quantity of which has not yet been ascertained, and, a little higher, another seam (4 or D) of coal, one foot in thickness. Next occur 17 feet of sandstone, and then a bed of slate, containing balls of good iron-ore in considerable abundance. It is thought that

[1] From Rogers's "Fourth Annual Report."

this larger bed may furnish three feet of iron-ore. Still ascending, we find 80 feet of brown sandstone, then a fire-clay, two and a half feet, and a seam of coal (5 or d), one foot thick, blue slate, three feet, brownish and then white sandstone, 40 feet; and, above this, a bed of coal (6 or E), not fully opened at the date of Prof. Rogers's final report, but stated to be four feet thick, presenting a good appearance at its outcrop, and which is now largely mined. Crowning the highest part of the hill, occurs a bed of conglomerate, 60 feet in thickness.

The dip of these strata, at the mines on Rocky Run, is gently westward; on Dutchman's Run, on the opposite side it is toward the east-southeast, while a few miles farther up the main branch of Rocky Run it is toward the northwest about 4°. On Red Run, the strata are nearly the same as at Ralston. Frozen Run enters Lycoming Creek on the west side, below Rocky Run. The coal-measures extend to the head of Frozen Run; the old Ralston mines, now abandoned, were on the hill between Frozen Run and Red Run. The strata here are very similar to those at Ralston, except that the coal-beds are not so thick.

Annexed is a section, made by Colonel Howard M. Smith, the general superintendent at McIntyre, showing the coal-seams, and their intervals of rock, the latter differing somewhat from those given by Prof. H. D. Rogers, in the "State Geological Report," which was taken at another locality, and before any mining had been done at Ralston. This may be taken as a typical section of the lower coal-measures, the coarse sandstone, or heavy conglomerate, tinged with red above Coal E, which caps the mountain, being probably the Mahoning sandstone. (*See* cut of this section on page 137.)

The lower conglomerate is here sometimes degraded into a sandstone, above which is the A vein, which is thin and rolling. Above are 26 feet of sandstone and 1½ feet of fire-clay. This brings us to the head of the shutes and coal-seam B, which is two feet two inches thick. Above it are eight feet of slate and six feet of sandstone, and then Coal C, which is three feet, with two inches of slate separating it into two parts. Then, in ascending order, are nine feet of slate and 60 feet of gray sandstone to the D vein, which has three feet of clear coal. Above

it are three feet of fire-clay and 84 feet of brown sandstone, and then the principal seam of coal E, which is five feet three inches, but the upper portion is inferior, and is not mined. The seam affords four feet four inches of clean coal—a good, free-burning steam-coal. Above it is a layer of two feet of slate, and then 50 feet of gray sandstone, and, on the surface, 15 feet of earth. Altogether there are 275 feet of coal-measures above the conglomerate.

FIG. 32.

se are unusually rich in an be picked up in great ng the slates brought es, the impressions of ng remarkably distinct The vicinity affords est mountain-scenery in and the hotels, deep ool, shady valley of Ly- are favorite places of tourist during the hot nmer. These are the Northern Pennsylvania situated directly upon a through-line of railroad.

The most striking object at the McIntyre mines is the inclined plane, in sight of the Northern Central Railroad, by which the railroad-cars are carried up the mountain (*see* Fig. 32). This is a very cheap and rapid method of overcoming a great elevation, and where, as at this place, the tonnage is altogether descending, no steam-power is necessary, the weight of the loaded cars drawing up the empty ones. The plane is 2,300 feet in length and 670 feet in height. Above the plane is a short piece of railroad, 1,500 feet in length, ascending 10 feet to the coal-

shutes. There are 32 double shutes, 29 feet in height, or 64 in all, capable of holding 2,000 tons of coal. The head of the shute is on a level with the second or B seam of coal. From this point another inclined plane ascends 176 feet of elevation, in a length of 360 feet, to the level of the upper or E seam of coal, from which the mining is principally done. The small or mine cars only are run over this upper plane. The whole elevation from the Northern Central Railroad, in the valley of Lycoming Creek, to the upper seam E, is therefore 889 feet, making that point 1,697 feet above tide-water. Coal-seam B is 502 feet below the B seam, at Barclay, in the same basin, if the levels are correctly taken. Three of the seams of coal have been opened, and found to be of workable size and good quality.

All of these mountains are covered with a dense growth of hemlock-timber of an excellent quality for building-purposes, and the first thing to be done when work is begun in establishing a colliery in this country, is to build a steam saw-mill. This is afterward always an important part of the fixtures of the mine, as large quantities of lumber are required for houses, shutes, and other purposes. The mining village at McIntyre is composed of 124 houses for dwellings for the miners and other employés, also a school-house, public hall, barns, shops, stores, etc., presenting very much the same general features as the mining towns in the Blossburg coal-region already described. The development of this coal-district has been unusually rapid, showing by its early success the energy of the proprietors, and the favorable circumstances under which the colliery was established. The mines were first opened in the fall of 1870, and in 1871 the company mined and sold 106,129 tons of coal, and thus far in 1872 their tonnage is at the rate of 160,000 tons per annum. They ship all their coal by railroad, finding a part of their market southward, and a part northward, in the State of New York, shipping it by the New York Central & Hudson River Railroad to Buffalo, Rochester, and the port of Charlotte, for the Canada market. The Northern Central Railroad, on which these mines are situated, is a large customer, using this coal in their locomotives.

The method of working the mines, and other particulars already given in regard to the several mines in the Blossburg

region, are not materially different at McIntyre. The McIntyre Coal Company was founded by the late Jervis Langdon, one of the most enterprising and successful coal-merchants in the State of New York. The present officers are his son, Charles J. Langdon, who is the president, and J. D. F. Slee, vice-president. The office of the company is at Elmira, New York.

3. TOWANDA.

Much that has been said in regard to the Blossburg region, the general descriptions already given of coal-works, and as to the character of semi-bituminous coal, will apply to the Barclay or Towanda coal-region, which is in the second basin. (*See* map on page 125.) Approaching it from the north, by the valley of the North Branch of the Susquehanna River, the railroad on its west bank runs through the Chemung group past Towanda, which is 699 feet above tide-water; thence leaving the river, it rises in a south-western direction up the valley of Towanda Creek, and its middle or Schrader branch, and by means of a self-acting inclined plane, similar to that at McIntyre, mounts to the summit of the Towanda Mountain, where the coal-seam B is found 16 miles from Towanda village, 1,320 feet above it and 2,019 above tide, between the main Towanda Creek and the branch above mentioned. The mountain is characteristic of the Alleghany range, of which it is the most northern and eastern finger-point, carrying upon it the farthest northeastern field. Its strata dip toward the southwest, and it presents a very steep escarpment, just 1,000 feet high above the level of Towanda Creek Valley. The coal occupies the highest summits only of the mountain.

Section across the Second Basin, showing the Coal Strata on the summits of Towanda Mountain, at Barclay, in Bradford County, Pa. Also the Anticlinal Valleys of Towanda Creek and Sugar Creek, on Axis No. II.

The annexed section, derived from the State geological map, taken in a north-and-south direction, shows in a beautiful manner what has been described in the general account of the Pennsylvania coal-basins, on page 123, that, although they are now on the summits of the mountains, yet the bending of the strata shows that they were originally in the valleys. The anticlinal valley of Towanda Creek at the base of the Barclay or Towanda Mountain, and that of Sugar Creek, farther north, are both cut out of an ancient mountain of which only a ridge of lower formation than the coal-rocks remains, between those streams. The dotted lines show the position of this anticlinal mountain between the second and third coal-basins, before it was carried away. Farther west, at Ralston, the Lycoming Creek finds its way southward through a very narrow valley which is a fracture across the second coal-basin. Farther northeast, at Greenwood, the mountain ends, the coal-basin itself is removed, and there is no more coal. But tracing it as the flexures of the basin show themselves in the formations below the coal, the line of the axis, or bottom of the basin, was followed by the State geologists up the valley of Wysox Creek, and into the northwest part of Susquehanna County. All this country is thousands of feet below the coal formation, as is proved in the account of the corresponding district north of the Blossburg region.

This region affords an illustration of what we will have occasion to discuss, under the head of the coal-trade, of the vital importance of a good quality of coal. For, while there is but a single seam of coal, and the area is far from being extensive compared to our other vast coal-regions, yet from the coal being good, and situated at a short distance from its market, a large business has sprung up, larger than some of the other regions have attained, with hundreds of square miles and numerous large seams of coal.

The Erie Railway Company, whose road follows the southern line of the State of New York, having become a large consumer of semi-bituminous coal for locomotive purposes, has leased the principal mines of this region, being those of the Barclay and Towanda Coal Companies. During the year 1869 they produced and burned for their own use 176,307 tons; in the year 1870, 196,310 tons; and in 1871, 263,928 tons. This is in addition to the coal they purchased at Blossburg, The only other mines

opened in the region are those of the Fall Creek Bituminous Coal Company, now owned by the proprietors of three large rolling-mills at Troy, New York, Messrs. Burden, Griswold, & Corning, who mined, in 1870, 77,025 tons, and in 1871, 129,095 tons, which was nearly all consumed in their own mills. Thus these parties have absorbed nearly the whole production of the region, in all 273,335 tons in 1870, and 393,023 tons in 1871, a quantity greater than some whole States in the coal-regions produced. The Barclay Coal Company was organized by Edward Overton, of Towanda, Pennsylvania (who was the first president), John Ely, and Edward M. Davis, of Philadelphia. Mr. Davis is now the president, and the largest stockholder. George R. Oat, of Philadelphia, was the president for eight years. Their railroad from the mines at Barclay to Towanda was completed in 1856, and a comparatively small business continued to be done by canal under great difficulties, from the want of transportation, until the year 1866. The Pennsylvania & New York Canal and Railroad Company then completed their railroad from Towanda to Waverly, when the Barclay Coal Company leased their mines and railroad to the Towanda Coal Company, the stock of which is owned exclusively by the Erie Railway Company. Since that period the production has been very largely increased, the coal being nearly all used on that railroad for locomotive fuel and in the railroad-shops. The mines are but 36 miles south of Waverly, which is 256 miles from New York, not far from the business centre of the road, and this is the first bituminous coal met with in going west. These circumstances, and the good quality of the coal for steam purposes, make this a valuable lease for the Erie Railway.

4. SNOWSHOE.

The land on which this coal-region is situated was surveyed by the deputy surveyor-general of the State, under land-warrants from the Commonwealth, at the beginning of the winter season. Being overtaken by a snow-storm, the surveying party were obliged to make snow-shoes on which to get down from the mountain to the settlement in the valley. These tracts of land having from this circumstance been called the "Snow-shoe Survey," this name was afterward given to the township in which they are situated, and to the mines.

This coal-region is situated in the first coal-basin of Rogers, in the western part of the county of Centre, and nearly west of Bellefonte. The Bellefonte & Snowshoe Railroad, 26 miles in length, connects the mines with that place, and it is intersected at Milesburg by the Bald Eagle Branch of the Pennsylvania Railroad, which runs from Tyrone to Lock Haven. From the junction with the latter railroad the Bellefonte & Snowshoe Railroad climbs the Alleghany Mountain by switchbacks 1,000 feet in a distance of 16 miles. Like the Tyrone & Clearfield Railway it then descends into the first coal-basin, but the descent is less, being here but 200 feet in a distance of six miles to the level of the slaty vein, No. 9 of the following section, while the descent at Phillipsburg is 530 feet.

The coal-field covers an area of at least eight miles in a north-and-south direction, and some four miles in an east-and-west direction, and is situated on both sides of the head-waters of Beach Creek, and a little farther west than it is represented on the map of the State Geological Survey.

No geological examination has been made of the lands except that of the State, and there is no published pamphlet descriptive of the region. Mr. James Somerville, the intelligent mining-engineer of the district, and who mines the coal by contract, gives the following approximate section of the coal-measures so far as they have been observed in the mining that has been done, and the explorations which have been made, which seem not to have been very thorough or extensive, and only made for mining purposes.

Section of coal-measures at Snowshoe in descending order:

1. On top of the hill seventy to eighty feet of slate and sandstone.
2. *Coal* E, five feet of clean coal, worked.
3. Fifty feet of sandstone and slate.
4. Two feet of limestone and iron-ore.
5. One foot of *coal* D.
6. Sixty feet of sandstone and slate.
7. *Coal* C, six feet, the Snowshoe and Karthaus vein with two slate partings, one of one inch, nine inches from the bottom, and the other six inches thick, and three feet from the bottom.

8. Forty feet of slate and sandstone.

9. *Coal* B, four and a half feet of slaty or bony coal.

10. Ninety feet of sandstone.

11. *Coal* A, six feet, of which three and a half are good coal.

Three of these coal-seams were worked in 1872, Nos. 2, 7, and 11 of the above section.

The coal is a good quality of semi-bituminous coal, free from sulphur, and well adapted for steam and rolling-mills. Professor Rogers's analysis gives it 78.8 per cent. of coke, and 21.2 per cent. of volatile matter and ashes. It finds its way to market by the railroad described, and then by the Bald Eagle Valley to Lock Haven, the Philadelphia & Erie, the Reading Railroad, the Northern Central, and other railroads eastward to the interior of the State. At present, from its situation in reference to the market, the production is limited to about 100,000 tons per annum, or a little less than that quantity.

A company, called the "Snowshoe Land Association," owns 40,000 acres of land in this vicinity, and monopolizes the coal. They conveyed a small portion of it, some 2,000 acres, to the Bellefonte & Snowshoe Railroad, the stock of which is owned by the same parties, and hence there is but the one mining company in the region, while at Phillipsburg there are sixteen. It is a substantial, careful, money-making company, chiefly composed of Philadelphia capitalists.

5. PHILLIPSBURG.

On the line between the counties of Centre and Clearfield, on the Moshannon Creek and its tributaries, is a coal-field belonging to the first coal-basin, which has within a few years grown into considerable importance. In 1871, there were 542,896 tons of semi-bituminous coal sent to market from this district. From Tyrone City, 224 miles west of Philadelphia, a branch of the Pennsylvania Railroad climbs the Alleghany Mountain over the Ponent red sandstone and the Vespertine of Rogers, which crown the highest parts of the mountain. But on these summits of the Alleghany Mountain the upper surface of the latter rock adjoins the base of the conglomerate stratum upon which all our coal-measures repose, there appearing to be a very thin if any Umbral or red shale interposed.

This formation changes to limestone toward the southwest. In Pennsylvania no valuable coal-seam has been developed in this Vespertine or in the Umbral formation. In Somerset County, in the Turkey-foot country, some small and as yet unproductive beds of coal do really occur in this rock or its equivalent. Farther southwest, in Virginia, they are also seen; but in Tennessee, coal-making began earlier than here, and a series of valuable coal-seams are found in the position equivalent to these formations. So, too, in the far northeast, in the Nova Scotia region, Dr. Dawson and Sir W. E. Logan describe thousands of feet of coal-measures below what are considered such in this State. A few coal-fossils found in them here may entitle them to be called sub-carboniferous, but they are worthless as coal-producing formations.

The railroad ascends 1,110 feet from Tyrone to the summit in 13 miles, and then descends 530 feet to the level of the lowest coal-seams, the first mining being done at Powelton, three miles beyond the summit. The most remote point from which coal is shipped to market on the main line of the road is Phillipsburg, 24 miles from Tyrone. There are, however, several branch roads between Powelton and Phillipsburg running to numerous mines on the several branches of the Moshannon Creek. The whole number of companies or operators in 1872 is sixteen, and their mines are scattered over an area of eleven miles or more in length. There is evidently a fine body of coal on both sides of the railroad, and found in the most accessible and convenient positions for mining. H. D. Rogers, in his preliminary report of 1841, states that the centre of the basin coincides very nearly with the general course of the Moshannon Creek, which is the line between Clearfield and Centre Counties, the strata on each side dipping gently toward the stream. In 1864, Professor J. P. Lesley, who examined the lands about Osceola, says in general terms that the Moshannon, and its twin branch, the Beaver, flow along the synclinal axis, or oscillate from side to side of it at no great distance, running north 55°, or 60° east. The dips are very gentle in the centre of the basin. Mr. L. G. Lingle, the mining engineer of the region, from whom much valuable information was derived, reports it at 50 feet in a mile and a quarter.

The following approximate *section of the coal-measures* is derived from Mr. Lesley's report, supplemented by information recently obtained on the ground. The lowest bed A outcrops at the level of the Moshannon Creek. There is said to be one small bed under it. The A bed measures five feet in thickness, the coal being compact, portable, inclined to ash, and somewhat sulphurous, weathering in peacock colors, a strong, burning coal, excellent for steam use and domestic purposes. It may have from 20 to 25 per cent. of volatile matter. The upper bench yields four feet, the lower bench one foot, and they are separated by one inch of slate. Other seams of a better quality having been afterward discovered higher up in the series, no mining is now done in coal A.

Coal-bed B outcrops 60 feet above A, the interval being composed of 15 feet of conglomerate and 45 feet of sand-rock and shale. Bed B is regularly divided into two benches, the upper one measuring two feet ten inches, and the lower one two feet, with six inches of slate between them. The upper bench yields a beautiful, pure, rich bituminous coal crystallized vertically, and apparently admirably suited for iron work. The lower bench yields a harder, more compact coal, with traces of a central slate, but will answer well for the same purpose. It is found, however, to be an irregular and variable bed, sometimes yielding 3½ to three feet, and sometimes only 2½ feet of coal. The bed will yield three to 3½ feet, and in many places four feet of fine coal, more valuable than that obtained from bed A, on account of its superior purity, but at the same time more liable to fracture in the carriage on account of its prismatic structure.

Between beds A and B lies a stratum of conglomeritic sandstone, thin bedded, a little false bedded, the pebbles of quartz from the size of a pin's head to a pea, forming low cliffs occasionally for one or two miles up the Moshannon, and apparently from 10 to 15 feet thick. It affords, no doubt, an easily recognizable key to the position of these beds, although care must be taken not to confound it with a higher stratum of sandstone of a different character under bed D, in such places where its conglomeritic character may happen to be wanting, and the mass becomes a simple coarse sand-rock.

Twenty feet above B is a 15-inch seam of coal (b); and 30

feet higher, or 50 feet above B, occurs coal C, which Mr. Lesley called a 2-feet bed, and which he considered worthless for mining purposes. It has, however, since been found to be 30 inches of good coal, and at one place 3½ feet of coal which comes out in large blocks, but it is not mined in this region. Above it is 50 feet of sand-rock.

Coal D is the bed in which the most of the mining in the region is done. It is remarkably pure and beautiful, and appears to be very regular, lying nearly flat, with a gentle rise toward the northwest under all the hill-tops. It measures about five feet of solid coal in most of the mines opened in 1872 in the district, being in some 4½ and never less than four feet, and always a clean seam of pure coal, but is everywhere covered with six inches of bony coal which comes down in mining, and is left in the gob. Under coal D are blue slates, a marked feature in the horizon.

About 35 feet above D is coal E, at the very summits of the hills, and about 200 feet above the level of the creek. It is a small bed one or two feet thick, and is worthless. Probably 25 feet over E is the Mahoning sandstone, of which detached blocks are found in the fields and woods, making a beautiful building stone. It is difficult to find it in place, but the masses of it on the surface are very numerous.

The base of the coal series under A is not easily examined, but there are sandstones thin and soft, then the small coal-bed, and then comes the great conglomerate, at the base of the coal-measures.

The mines have a good roof of very hard, fine-grained sandstone. The gangways and headings are made nine feet wide, and the rooms 20 feet, the pillars ten feet, and the props are set about four feet apart. No powder whatever is used. The coal is undermined, five or six feet being spragged or supported by short props, while working under; it is then sheared down at the sides and wedged down, a good miner taking out six or eight tons per day. No pumping is required, the coal, as before described, dipping toward the creek from both sides of the stream. The facilities for mining are excellent, and mines can be opened very cheaply. The coal finds it way to market at Philadelphia by the Pennsylvania Railroad, a distance of from 240 to 250

miles, and a portion of it to New York city, and is sold at a low price, with a small profit only. It is evidently a good blacksmith's coal, making a hollow fire, and is well suited for steam and rolling-mill use. The finer portions of the coal burn very readily, swelling and forming a hard coke, and it is quite free from sulphur. That it has obtained a market of half a million of tons in a few years, is of itself conclusive evidence of its good qualities as a steam and iron working coal.

The following is a correct list of the various mines of the Phillipsburg region, given in geographical order, beginning at the nearest or most easterly.

Names of Mines.	Operator.	Railroad.
Powelton	Powelton Coal & Iron Co.	Tyrone & Clearfield Railroad.
Clearfield	Clearfield Coal & Iron Co.	Beaver Run Branch.
Moshannon	Moshannon Coal Co.	" "
Beaverton	Kittaning Coal Co.	" "
Sterling	Sterling Coal Co.	" "
Eureka	White & Lingle	" "
Franklin	Kittaning Coal Co.	" "
Penn	Blattenburgh & Hines	" "
Enterprise, No. 1	Enterprise Coal Co.	Tyrone & Clearfield Railroad.
Enterprise, No. 2	Enterprise Coal Co.	" " "
Mapelton	Mapelton Coal Co.	Phillipsburg Branch.
Union		" "
Derby	Derby Coal Co. of Pa.	" "
Decatur	Decatur Coal Co.	" "
Morrisdale	Morrisdale Coal Co.	" "
New York		" "

This Tyrone and Clearfield branch of the Pennsylvania Railroad extends on northwestward to the town of Clearfield, in the second coal-basin, and on the west branch of the Susquehanna River. The country is broken and undulating with well-rounded hills, and without the precipitous sandstone cliffs which characterize the formations lower down in the geological scale. Between Phillipsburg and Clearfield, however, are a number of miles of level swampy country, forming a sort of natural meadow. The upper and more valuable of the coal-seams crop out west of Phillipsburg, but it appears not unlikely that the lower strata of the coal-measures saddle over the anticlinal between the first and second coal-basins, as they do, according to Prof. Rogers's report, a little farther south, between Mount Pleasant and Clearfield.

No mining was done near Clearfield in 1872, except for local use, and very little is known in regard to the geology of the vicinity. The seams of coal that have been opened, and which are easily found all around the town, are said to be thin, not exceeding about three feet or less, and the larger seams, worked in the Phillipsburg, Osceola, and Powelton or Moshannon basin, have not been found here. None of the known sandstones or other horizons having been identified, the geological level of the place is no better known than it was when Prof. Rogers visited it in 1840. In his report for that year, he says much difficulty was experienced, in the district around the town of Clearfield, in identifying the coal-seams of neighboring localities, and after close investigation, aided by frequent diggings, the stratification remains quite obscure. He was in doubt to what cause to attribute the intricacies of the region; whether to local displacements of the strata, sudden variations in the thickness, or an insufficient collection of facts. The largest bed was at Reeds, near the bridge over the Susquehanna River, two miles from Curwinsville, which was three feet six inches thick. Like most of the beds in the southeastern basins, it affects a species of columnar structure, being traversed by innumerable vertical fissures, which render it somewhat friable. His analysis gave 73 per cent. of coke, and 27 of volatile matter and ashes.

There are indications of a number of seams of coal in the hills, some of which have been opened, particularly one, two feet ten inches thick, between 40 and 50 feet above a stratum of sandstone that occupies the bed of the river.

At a very early period coal was mined near Clearfield in the bed of the west branch of the Susquehanna, run down to market along the lower Susquehanna in arks in time of freshets, and used for blacksmithing. This was among the earliest attempts to send bituminous coal to market in the State of Pennsylvania.

6. JOHNSTOWN.

In all the coal-regions previously described, the coal is mined for sale, as is generally the case in America. In the locality about to be described, on the contrary, a large business is done in the mining of coal, which is consumed at the mouth of the

mines by the same parties who produce it. At Johnstown, in Cambria County, on the Pennsylvania Railroad, 78 miles east of Pittsburg and 276 miles west of Philadelphia, is one of the finest developments of the coal and iron resources of Pennsylvania. Here we have not the wealth provided by Nature alone, but there is added all that capital, enterprise, and science can do for the prosperity of a country. What greater blessing can be conferred on a locality, in a material aspect, than the building up of a vast industrial centre like this? In the year 1871 there were mined at Johnstown 263,472 tons of coal, all of which was used there mainly in the manufacture of 25,027 tons of pig-iron, from the coke made of the coal, 160,363 tons of rails and other wrought iron, and 1,907 tons of steel, the Bessemer Works, for the latter purpose, being just completed. The ore and limestone were also produced in the same place and on the same ground with the coal, all these materials lying in successive horizontal beds over each other, and above water level in the steep hills surrounding the works, and requiring no transportation except to bring them out of the mines. The lower coal-measures alone are found at Johnstown, of which the following is a section recently made in the descending order, a portion of it including the seven-feet seam of coal A, being below water-level of the Connemaugh River.

	Rock, Feet.	Coal, Feet.
The Barren Measures, Sandstone	65	
" " " Light-colored Slate	260	
" " " Johnstown Iron Ore	1½	
" " " Slate	76	
Coal E, called Coke-yard Seam		3½
Slate	62	
Coal D, called the Limestone Seam		2½
Limestone	5	
Slate	46	
Coal C, just above the River, called the Cement coal, worked constantly		3½
Cement Clay, extensively used all over the country	8½	
Slate	98	
Coal B, called the Peacock Coal, good		3¾
Fire Clay	5	
Slate	63	
Coal A, good 4 feet, and 3 feet, and 1 foot Slate between	1	7
	691	20

Conglomerate or Farewell Rock.

12

This gives the thickness of the lower coal-measures from seam A to E at 308½ feet, containing 20 feet of coal. The position of the beds of iron ore is given in a notice of the iron ores in another part of this volume.

It would be difficult to calculate the number of persons who are directly and indirectly furnished with employment in every possible variety of occupation, or who are otherwise benefited, by means of the fortunate combination in this favored district, of the materials which constitute the basis of this great and important business. And yet there are probably many other places as highly endowed by Nature as Johnstown, which are yet reposing in the undisturbed quiet of the vast wilderness coal-regions described in this volume. What they have been waiting for is, the men with the brains, the industry, energy, the indomitable spirit, and the acquired knowledge of these peculiar branches of business to qualify them to organize and conduct large establishments like these; and then, aided by the necessary capital, to bring from the earth its deeply-hidden treasures, thereby furnishing honest work and good wages to thousands of men, and giving support and all the blessings of civilized life to tens of thousands in the surrounding country. Those who bestow millions on the starving and destitute are not greater benefactors of our race than those who, like the Cambria Iron Company, give to the man who is willing to work constant employment and regular wages. Our great mineral resources are as nothing until they are brought into use.

7. CAMBRIA COUNTY.

Along the line of the Pennsylvania Railroad in Cambria County are at least ten firms and individuals engaged in mining coal, which is shipped on that railroad. The railroad company report 228,808 tons of coal received for transportation in this district on the western slope of the Alleghany Mountain. The points at which it was received were Galitzin, Lilly Station, Summerhill, Mineral Point, and the vicinity of South Fork.

In the extensive region of country from the Pennsylvania Railroad along the Connemaugh River, to the Philadelphia & Erie Railroad along the West Branch of the Susquehanna, there may be some other coal-works not here noticed; but

there are none of magnitude, and those which have been described may be taken as favorable examples of the whole district. The seven semi-bituminous coal districts just described, and the Broad-top, are at present much the best developed and most productive of that extensive portion of the State in which the lower bituminous coal-measures alone occur.

8. BROAD TOP MOUNTAIN.

The appearance on the map of Pennsylvania of some of the northern coal-fields, such as the Blossburg, McIntyre, and Towanda, conveys to the observer the idea of their being detached from the great body of the Alleghany bituminous coal-field which covers the western part of the State. But while they are thus separated, so far as the coal-measures are concerned, yet the great flexures of the strata which formed the six great coal-basins extended far below that formation, and the basins can be seen and followed very readily from the Maryland to the New York line, leaving no doubt of their identity in the various parts, although traced across deeply denuded valleys and ravines, and over considerable spaces where no coal is found. The Broad Top Mountain coal-region, however, is strictly and geologically an independent or isolated coal-field, situated 40 miles east of the declivity of the Alleghany Mountain, which forms the eastern boundary of the first bituminous coal-basin. Parts of it are situated in Bedford, Huntingdon, and Fulton Counties, and the outlet to market for its coal is by the Huntingdon and Broad Top Mountain Railroad, extending from the coal-field to the Pennsylvania Railroad at Huntingdon, 36 miles. From Huntingdon the coal is carried by the Pennsylvania Railroad to Philadelphia, 203 miles, and to intermediate places where a market is found.

Mr. J. P. Lesley took up the study of the Broad Top coal-regions in 1855, and made a survey of the 80 square miles it covers. He reports that Trough Creek Valley, Plank Cabin Valley, and Wells Valley, in Huntingdon and Bedford Counties, form a trench around the *Broad Top Mountain* with its coal-basin, and Brush Creek Valley is attached to the ring at its southern end. This ring or circular valley is a deep depression worn out of the red shale by the Juniata River and other

water-courses, 1,000 feet deep below the crests of the enclosing mountains. It is usually but one to two miles wide, but at its northern end forms a triangular opening six miles wide at its base and 18 miles long, rising to the top of the knob of Terrace Mountain, overlooking the county of Huntingdon. In the centre of this ring rises the mountain mass of the Broad Top, containing 80 square miles of coal-measures disposed in six parallel basins, and crowned with a central peak, "the Broad Top," rivalling in height the summits of the Alleghany Mountain, 40 miles distant. Near the summit of this peak remains a small round patch of the Pittsburg or Westmoreland gas-coal bed, a few acres in extent; the sole relic of that vast deposit of this famous bed remaining in all the country between Cumberland in Maryland on the south, Blairsville in Indiana County on the west, and Donaldson in the Pottsville basin of the anthracite coal-region on the east.

The succession of the measures is not different from that of Western Pennsylvania and Eastern Ohio. There is a base of carboniferous conglomerate lying upon the red shale, from 100 to 200 feet thick, massive, homogeneous, seldom conglomeritic, except as a whole. Over this is a series of lower coal-beds, then the barren measures, and, over all, the Pittsburg bed, the beginning of the upper series. The purple shales of the barren measures are, however, wanting, their place being supplied by ferruginous sandy shales. The coal-beds are mostly identified with those of the head-waters of the Ohio, not by limestone companions, for these are almost entirely absent, nor by the beds of iron-ore, which are rare, and on which, at any rate, little reliance can be placed, but by their order in the series, by certain general characters, and by their relations to the two conglomerates, the one at the base of the whole system, and the other at the base of the middle member of the barren measures, a rock as widespread as the true conglomerate, and known as the Mahoning sandstone. In the heart of this rock is a workable bed, and between it and the lower conglomerate are two others with four or five small beds, the larger bed from five to ten feet thick, the lesser ones from one to three. In the barren measures, or middle series, which are 400 feet thick, are several very small seams of carbonaceous matter.

The Pittsburg bed of coal, and 200 feet of the upper coal-series, with no workable beds as yet known, but with one thin limestone, occupy the four geographically highest summits of the basin, the whole thickness of coal-measures in which is about 900 feet.

The structural results of the survey are interesting, for they exhibit, in cross sections, the whole basin, seven or eight miles wide, divided by a main anticlinal into two principal troughs, and these subdivided into numerous narrow synclinals, or swamps, by a system of horsebacks, not parallel to it, but traversing the basins at a low angle with their sides, and issuing, as in the Wyoming Valley and other coal-fields, into the red-shale valleys, through the walls of conglomerate. The larger of these synclinals form northeast normal terminal knobs overlooking the great valley of Trough Creek, but, southwestward, flattened out along the crest of the conglomerate, which runs very obliquely across them.

The Huntingdon & Broad Top Mountain Railroad was completed in 1856, when the first coal was sent to market. The total production of the region has been 3,942,005 tons in sixteen years; that of 1871 was 319,625 tons, and the average has been about 300,000 tons per annum for the past twelve years. The coal is sold at Philadelphia, and a portion of it in New York city. There is also a market along the line of the Pennsylvania Railroad.

A careful analysis was made of Broad Top and of Pittsburg coal, for the Pennsylvania Railroad Company, in 1859, with the following general results:

General Analysis.

	Broad Top.	Pittsburg.
Water	0.30	1.30
Volatile matter	17.55	31.45
Fixed carbon	74.65	61.45
Ash	7.50	5.80
	100.00	100.00

Organic Analysis.

	Broad Top.	Pittsburg.
Carbon	79.59	78.26
Nitrogen	1.39	1.67
Hydrogen	4.35	5.20
Oxygen	5.02	6.73
Water	0.30	1.30
Sulphur	1.85	1.04
Ash	7.50	5.80
	100.00	100.00
Specific gravity	1.330	1.285

X.

BITUMINOUS COAL-REGIONS OF WESTERN PENNSYLVANIA.

I. THE LOWER COAL-MEASURES.

Rivers and General Topography.—The Pennsylvania bituminous coal-field may be considered as a great and complex basin, for such it really is. Its boundary on the east or southeast is very well defined by the abrupt declivity of the Alleghany Mountain, as it is here called, being what is called the Cumberland Mountain in Virginia and Tennessee, which is like a steep, sloping wall, about 2,000 feet above the sea, and not of that great altitude which the often-repeated title of Alleghany Mountain is apt to lead us to suppose. West and northwest of this long, straight rim of this vast basin, lies this coal-field, which is only the northeastern extremity of the trough-shaped plain or table-land which ranges hence uninterruptedly southwestward to the centre of Alabama. The courses of the streams show that the general surface ascends gradually toward the north, where the Alleghany River drains it throughout. Rising in Potter County, this river runs into New York, turns westward past Olean, and runs into Pennsylvania again, pursuing a southwest course to Franklin, entering the coal-basin at Warren. From Franklin it runs across the coal-field southeastward to Mahoning Creek, through the sixth and fifth basins. From the Mahoning it runs southwestward, following the coal-basin in a winding course to Pittsburg. It runs through a deep and comparatively narrow trench in the coal-basin. Prof. Rogers accounts for its changes of course, from southeast to southwest, by the action of

two great currents of eroding water, when the continent was elevated, the main one flowing southwestward from the Alleghany Mountain, and the other southeastward from the region of the lakes, and cutting valleys at right angles to each other.

In Potter County, the Alleghany summit is 1,650 feet above tide-water; in McKean, 1,900 feet. Thence, following the crest, it declines to Indiana County; thence it ascends to the summit between the Juniata and Conemaugh, where it has an elevation of 2,790 feet, and thence continues at about 2,550 feet, at which elevation it passes into Maryland—the elevation of the Pennsylvania Railroad tunnel being 2,161 feet.

From the summit of the Alleghany the country declines both ways, but it is only with what lies west of it that we are concerned. This district, west of the Alleghany water-shed, is not a simple slope, but is a great, irregular trough, the southern portion being, in fact, a series of parallel troughs, caused by the ridges of Negro Mountain, Laurel Hill, and Chestnut Ridge, rising up, sometimes 1,200 feet high, within the southeastern part of the coal-field, the Conemaugh and Youghiogheny Rivers crossing them, and cutting gaps down through them to their base. Around the northwestern borders of the basin, where the waters emptying into the Alleghany separate from those flowing into Lake Erie, the elevation is about 1,200 feet. The northern part of the basin is also geologically undulated into six coal-basins, as hereinafter described. The northwestern tract of the coal-field, the fifth and sixth basins, gradually subsides in level toward the southwest, and the strata also decline in the same direction, but at a somewhat faster rate than the surface does, and hence the southwestern portion of the State contains a greater thickness of coal-measures than the northeastern. Indeed, in Potter, McKean, Warren, and parts of the counties south of them, the table-land is almost entirely destitute of the coal-producing parts of the formation, and is only overspread by the conglomerate and other older rocks, known to underlie any workable coal-beds.

The Six Basins described—their Structure and Coal-seams.

In order to acquire a clear conception of the singular manner in which the coal-strata of the bituminous region of Penn-

sylvania are distributed, it is necessary to keep in mind its structure as before described. The whole crust of the earth in this locality, so far as it can be examined, is not found in the horizontal position which is usual with water-formed rocks, but it is thrown into a number of vast flexures or waves, showing, however, less violence than the region east of it. These undulations run nearly parallel with each other, and in a general northeast and southwest direction. The line running on the summit of one of these waves is called an anticlinal axis, and that which would follow the bottom of the trough or basin between two of them is a synclinal axis. These features of the formations are much older than the rivers, mountains, and valleys, with which they have little connection. The hardness and thickness of the rocky strata, and many circumstances other than the flexures, have governed in the formation of the physical features of the present surface. We must, therefore, in studying the coal-districts, look at the original interior relative position of the strata previous to the denudations and other subsequent changes.

Within this great coal-basin the anticlinal waves of the strata are important geological features, and five of them extend in a northeast and southwest direction, some of them entirely across the State, and others across a large part of it, dividing the whole bituminous coal-region into six separate basins (*see* sketch-map of the flexures, on page 117). There are two of the anticlinals outside of the coal-field, making the seven borders or rims of the six basins, and within those larger basins there are also some smaller basins formed by sub-axes. In the southeastern part of this coal-region the Negro Mountain, Chestnut Ridge, and Laurel Ridge, bring to the surface lower rocks than the coal-measures, and hence form long, narrow, barren areas within the body of the coal-field, the summits of these ridges or mountains being destitute of coal. Farther to the northwest, similar anticlinals exist, throwing the coal-field into troughs or basins, without, however, bursting through them, but permitting the lower beds to arch over from one basin to another, and insulating only certain parts of the upper beds.

The result of this peculiar structure of the anticlinal axes

or ridges, with the basins between them, will be readily seen when we add that there is a general rising of the strata as we proceed northward. The basins, as we follow them from the southwest in a northeastward direction, must necessarily grow shallower as respects the thickness of the coal-rocks sheltered within them. First, the higher or Pittsburg bed disappears, leaving only the lower ones in the basins, then the lower seams of the lower coal-measures alone are found. Next, the backs of the anticlinals or ridges come out destitute of coal, leaving in the vicinity of the West Branch of the Susquehanna only long, narrow fingers of coal, with the intervening anticlinal spaces between. And, last of all, we find the formation ceases to be continuous, being prolonged only by a few scattered patches occupying the highest knobs of the long and narrow synclinal table-lands in which the basins terminate. "Leaping, as it were, from summit to summit, these detached masses of the coal-formation lead us, but often by long skips, to within a few miles of the North Branch of the Susquehanna River, on the east, and the New York line, on the north."

FIG. 34.

Map of a Part of Pennsylvania, showing the Coal Areas of the State, *in black*; also the Mesozoic Red Sandstone Formation, *obliquely lined across*.
The six Allegheny Coal-basins are: 1, Sullivan County; 2, Towanda; 3, Blossburg; 4, St. Mary's; 5, Clarion; 6, Western Pennsylvania.

These six original basins of this great coal-field will now be described in a general way: first repeating, in order that non-geological readers may fully understand the description, that an anticlinal is the arch or top of the wave, or the upper rim of the basin, like the ridge on the roof of a house, and the synclinal the inverted arch or bottom of the trough or basin. As the latter are the localities where coal is found, it is more important that they should be traced. The lines now to be described, therefore, are from northeast to southwest, and are intended to show the centre or bottom line of each coal trough or basin where the largest quantity, if not the only coal, is found. All through this Pennsylvania bituminous coal-region the usual style of map-making does not apply. The top of the map should be northeast, the bottom southwest; the right hand southeast, the left hand northwest.

The First Basin.—Mahoopeny, Farrandsville, Snowshoe, Phillipsburg, Johnstown, and Somerset County.

The first coal-basin is known in the counties of Wyoming and Sullivan as Mahoopeny Mountain, and includes the Sullivan County semi anthracite coal-field. The southeast rim is an anticlinal axis not numbered with the five great axes of the bituminous coal-region, being outside of it. It is a prolongation of the great axis of Bald Eagle Mountain, Nippenose Valley, and Muncy Valley, and crosses the North Branch below the mouth of Tunkhannock Creek.

The other, or northwestern limit of this trough is a long, gently bending anticlinal axis, the centre line of which crosses the North Branch of the Susquehanna, near Wyalusing Falls. Of course, the basin, or synclinal, No. I., lies between these two anticlinals or rims of the trough.

The greatest dip exhibited by this basin on the north is along the waters of the Loyalsock, in Sullivan County. The bed of the peculiar semi-anthracite coal now being mined and sent to market by the Sullivan & Erie Railroad is found between the South Branch of Loyalsock Creek and Birch Creek, this being, in the north, probably the deepest part of the basin. It is described at the close of the chapter on the Pennsylvania Anthracite Regions, page 62.

The first basin takes in the Farrandsville coal, on Quin's Run, in Lycoming County, on the West Branch of the Susquehanna, and farther southwest the Tangascootac region, where the coal-measures expand over a considerable extent of country. Farther southwest it includes the Snowshoe and Phillipsburg districts. Both of these being productive, a special account of them has already been given.

From Phillipsburg southwest, the centre of the basin runs along Moshannon Creek, the strata on each side dipping gently toward the stream. Thence it runs on up the headwaters of Clearfield Creek to Mount Pleasant and into the Conemaugh River country. It will be noticed that the kind of coal produced in this basin is not similar throughout. First, on the northeast is the semi-anthracite of Sullivan County, being the last anthracite coal produced in a northwest direction. The coals produced in the other localities mentioned are altogether different, being semi-bituminous. The lines of metamorphoses, therefore, do not coincide with those of the basins, but are more in a direct northeast and southwest course, the first basin inclining more toward the east in this its northern extremity.

Farther southwest, and particularly south of the Conemaugh River, the first basin is subdivided by other ridges or anticlinals into three sub-basins. The first lies between the Alleghany Mountain and Negro Mountain, which issues from Maryland into Somerset County. The second, or Stoyestown sub-basin, is a less important synclinal, running from near Ebensburg, eight miles east of Johnstown, and in the general aspect of the country scarcely makes its presence known. The third, or Johnstown sub-basin, lies between this and Laurel Hill.

Coal in the First Basin.—Beginning at the Maryland line with the three sub-basins of the first great basin, south of the Pennsylvania Railroad in Somerset County, and proceeding northward, we first notice the Elk Lick Creek region between Berlin and Salisbury on the line of the Pittsburg & Connellsville Railroad, where there is a fine development of the coal-measures. The synclinal axis or bottom of the trough lies considerably east of the centre of the valley, and the coal-meas-

ures are of much greater thickness in this vicinity than in the tracts farther north. The large or Pittsburg bed is here discovered high up in the series which, from the shallowness of the basin elsewhere, has not been preserved from denudation. This coal lies near the top of a long hill between Castleman's River and Elk Lick Creek, and south of the Connellville Railroad, but, as the basin rises northward, the large coal-seam disappears at Castleman's River. There are here 800 feet of coal-measures, as ascertained from borings and from the strata above water-level at Elk Lick. In the boring were noticed three coal-beds: A is three feet thick; B, five feet, but separated at the falls of Elk Lick by a heavy bed of fire-clay. The third coal of importance, E, is between two and three feet, and rather poor coal. Between B and E occur two smaller beds, C and D, along the edges of the basin. These are also seen in Ligonier Valley and on the Conemaugh. This completes what has been called the lower coal-measures, and brings us to the so-called Barren Measures, which here belie their name. The next bed in the ascending order, F, is here four feet thick, and of good quality. It is accompanied by three insignificant seams, the overlying one being two inches thick while the uppermost of the inferior ones is 12 inches. Elsewhere in the other basins to the northwest, it assumes a more trivial thickness. The coal-bed G, also a widely-diffused stratum, measures one foot six inches in thickness. Still rising in the series, we find another though a very thin coal-bed, g, said to be one foot thick. This bed becomes three feet thick in the basin between Laurel Hill and Chestnut Ridge. Still ascending the hill on the east side of Elk Lick Creek, we meet with the great bed H or Pittsburg seam, nine feet in thickness. Indications of this appear in other localities near the Maryland line. It also occurs in Ligonier Valley, where it is underlaid at a distance of 20 feet by a bed of limestone measuring six feet thick.

A little farther north in this first sub-basin, at Berlin, the upper or large seam is not met with, but three lower seams are mined for the supply of the town, the upper one affording five feet of true coal; the middle one, considered the best, is four feet, and the lower one three feet. The space between the

upper and middle one is about 60 feet, and that between the middle and lower ones from 40 to 50 feet.

The strata in the Alleghany Mountain here generally dip to the westward at an angle varying from 15° to 20°, causing the overlying coal-measures to ascend the western slope to within a mile and a half of the eastern crest, and, in cases of denudation on its eastern escarpment, the coal appears as if it outcropped east of the main summit of the ridge.

Second Sub-Basin.—From Somerset southward there is but one wide basin between Negro Mountain on the east and Laurel Hill on the west. The synclinal axis or line of meeting of the western and eastern dips is not through the centre of the basin, but immediately along the base of Laurel Hill, coinciding very nearly with Laurel Hill Creek, which, like so many other streams, flows along the line of axis, while its distance, on the other hand, from the western foot of Negro Mountain is between five and six miles. The body of the coal-measures in the deeper part of the basin affords but four or five seams of coal, and these of deteriorated thickness. But a coal-seam six feet in thickness is found low down on the banks of the Youghiogheny, near Smythfield, from which a considerable quantity of coal is derived for the supply of the town.

Farther north toward Somerset, coal is abundant in the hills lying west of Castleman's River, but near and north of Somerset the coal-seams appear to lie buried beneath the more unproductive strata that occur near the surface. The Negro Mountain axis vanishes north of Stoyestown, and causes the whole valley between the Alleghany Mountain and Laurel Hill to have the structure of a single basin. Eight miles east of Johnstown, however, an axis of elevation occurs, before mentioned, which can be traced south-southwesterly toward Jennersville, and there is a second anticlinal axis which passes between two and three miles east of Stoyestown and east of Somerset, through the middle of Negro Mountain, which commences here as a regular ridge.

From Johnstown to Somerset, however, the rocks which saddle over or overlie these axes appertain exclusively to the coal-measures, except in the bottom of ravines where the underlying strata expose themselves.

The opening of the Pittsburg & Connellsville Railroad through the southern portion of these two sub-basins has rendered the reproduction of these details in regard to them, from Rogers's reports, more necessary than they otherwise would have been.

The Potomac or Cumberland Basin, in Pennsylvania.—East of the main Alleghany Mountain in Somerset County, and east of the first coal-basin, is a small basin which should not be overlooked, being the northern extremity of the Frostburg and Cumberland (Maryland) basin which crosses the State line. (*See* Miniature Map of Pennsylvania, on page 185.) For, although the big bed or upper coal-measures of the Frostburg region seem to terminate in Maryland, yet the basin itself, with the lower coal-measures, and probably the upper also, reaches into Pennsylvania. This basin begins toward the head of Stone Run, in Hardy County, Virginia, ranging through Maryland, where it has been fully described as the Cumberland coal-region, and terminating at Will's Creek in this State. It is here bounded on the east by the Little Alleghany, and on the southwest by the Savage Mountain. The Pennsylvania portion of this basin, which is in the southeast corner of Somerset County, may be estimated at five miles in width, measured along the State line, and seven in length. It is believed that little or no coal will be found north of Will's Creek. The highest seam enclosed in this trough is that which is principally worked. It extends, with a very undulating line of outcrop, near the summit of a long, irregular ridge of considerable elevation, lying about midway between the Little Alleghany and Savage Mountains, intersected by numerous transverse valleys of denudation. These interrupt the regular range of this upper coal-seam, but thereby greatly favor the operations of the miner by exposing a more extensive outcrop. Its average thickness, as ascertained in numerous places where it has been opened, is about eight feet. The identity of this with the great seam worked at Frostburg is highly probable, as well from the character of the coal itself, and the accompanying shales, as from the similiarity of its position upon the ridge. Several other good seams of coal, situated lower in the series, in thickness from three to five feet, are known to exist. This basin is crossed near its north-

ern end by the Connellville Railroad, which was completed in 1871.

Second or Towanda Basin.—Barclay, McIntyre, Renovo, Karthaus, Clearfield, and Ligonier Valley.

The synclinal No. II., or centre bottom line of the second basin, can be traced from the northeast part of Susquehanna County in a southwest direction, crossing the North Branch of the Susquehanna, near Towanda, in Bradford County; thence running southwestward, it passes through the Towanda or Barclay Mountain, the mountain plateau of the second basin being split nearly from one end to the other by the Middle or Schrader Branch of the Towanda Creek.[1] The synclinal keeps in the hills, and runs from one to four miles southeast of that creek, and crosses Lycoming Creek one mile north of Ralston.

This portion of the basin contains the Barclay mines, the farthest east and north of all bituminous coal, and Ralston coal-region, the one being on the northeast extremity of the mountain near the North Branch of the Susquehanna, and the other at the southwest extremity of the same, where it is cut through by the Lycoming Creek, where are situated the McIntyre mines.

Proceeding along the line of this second basin southwestward on the first fork of Pine Creek, conglomerate and a little coal in thin seams are found, and farther southwest toward the main Pine Creek. Tracing this second basin in a northeast to southwest direction as a continuous trough it reaches the West Branch of the Susquehanna, near the mouth of Young Woman's Creek, which it crosses, passing afterward Kettle Creek near its mouth. The Renovo mines are in the second basin. But in this part of the country immediately north of the river the basin is very shallow, only a thin remnant of the coal-measures capping the very highest hills.

Farther southwest the second basin seems to run near the West Branch, and parallel to it for a great distance through Clinton, Clearfield, and Indiana Counties. It is a very broad and extensive belt of country, and there is a remarkable regularity in the position of the coal, iron-ores, and other less

[1] See section on page 167.

valuable strata. Of the coal there would appear to be at least three seams of moderate dimensions, but of workable thickness in the lower coal-measures, and in many localities more and larger seams. To give all the details that might be collected would occupy too much space; illustrative examples only can be given.

At Karthaus, in the northeast corner of Clearfield County, the coal-measures in the hills are quite productive, showing ten seams of greater or less size, the upper one six feet thick. The basin continues southwest past Clearfield, the whole country here between this basin and the first basin at Mount Pleasant being covered with coal-measures, none of the lower formations appearing on the dividing ridge between Clearfield and Phillipsburg. Karthaus is near the line between the semi-bituminous and bituminous coal. There is no mining done in the Karthaus region except for neighborhood use, there being no railroad connecting it with the Philadelphia & Erie Railroad. The mining done at Renovo is by a company called the Karthaus Coal & Lumber Company; but that is not the locality properly called Karthaus. The vicinity of Clearfield is described at the conclusion of the section on Phillipsburg.

The lower coal-measures are finely exposed along the Conemaugh at Lockport, and other places farther north in the second basin, along the valleys of Yellow and Two Lick Creeks in Indiana County. Here is the northern termination of Chestnut Ridge, which divides the second from the third coal-basin. North of the turnpike from Ebenburg to Indiana, neither the ridge nor its anticlinal axis is perceptible.

The Laurel Hill, which separates the first and second basins, on being followed northward, also loses its features as a distinctive ridge a little south of Black Lick Creek, in the southern part of Indiana and the central part of Cambria County. Indeed, even some miles south of this the ridge is very much reduced, and its axis greatly flattened down. At the extremity of the ridge, coal is found in abundance exposed in the valley of Black Lick Creek.

South of the Conemaugh this is topographically the best-defined basin in the bituminous coal-region, simple and symmetrical, and having on each side of it a long and regular mountain, and the synclinal axis of the trough coincides with the

centre line of the valley. It is called *Ligonier Valley*, bounded by the Laurel Hill on the east, and the Chestnut Ridge on the west, and is on the east side of Westmoreland and Fayette Counties. These mountains seldom rise to a greater height above the valley than 900 feet, and rest on a base from three to five miles wide. These bounding mountains are broad, single, parallel anticlinal ridges, of even summits and remarkably regular outline, with a single anticlinal axis of elevation traversing the whole length of each. The third formation below the coal rises to the day only near the crest of each mountain, sometimes only the conglomerate rides over all, arching the axis and standing up in humps along the summit of the mountain. The flanks of the mountains consist, in great measure, of one formation, the conglomerate, dipping nearly parallel with their slopes, and the rocks of the coal-series leaning against their base, or rising to a moderate height along their lower acclivities. The formation is easily seen at the gaps of the Conemaugh and Youghiogheny Rivers.

This coal-basin of Ligonier Valley maintains a very regular breadth of about six or seven miles throughout its entire length from the Conemaugh to the Youghiogheny River. The coal-measures extend entirely across the valley, resting against the base of each mountain, and rising a moderate distance up its slopes. The inclination of the rocks is generally very gentle, being seldom more than 7°. The only exception to this is in the lower slope of the Laurel Hill along the eastern edge of the valley; the dip amounts in some places, especially near the Youghiogheny, to 30°. In the central tracts the strata are nearly horizontal, over a considerable breadth of the valley, but, being deeply trenched by the valleys of the larger streams, their mineral contents are well exposed and placed accessible to the miner.

The central parts of the basin are occupied by the barren-measures, capped, in one locality south of the Conemaugh, by the Pittsburg coal-bed. Along the exact centre of the basin, in Westmoreland County, runs a high but very narrow hill, dividing, as it were, the valley into two, through which, horizontally stratified, crops out the Pittsburg coal-seam, from seven to ten feet thick.

The Pittsburg seam, found in this range of hills, in the centre of Ligonier Valley, from Fairfield to Ligonier, has been opened in many places. It produces coal of a superior quality, and therefore the thinner beds in the neighborhood, near the bottom of the series, which measure respectively about three, four, and five feet, are almost wholly neglected. It follows nearly the summit of the ridge, which ranges along the centre of the valley, to within about three miles of the Conemaugh. This Ligonier Valley is another of Pennsylvania's great treasuries of coal, without even a railroad passing through it in a north and south direction. The Connellville Railroad crosses it east and west along the Youghiogheny and across the first basin by the valley of the Castleman River, and the Pennsylvania Railroad by that of the Conemaugh. It must bide its time; at present the market for coal is otherwise supplied.

Indeed, the only considerable production of coal from this very extensive second basin, 250 miles long, from the West Virginia line to within thirty miles of that of New York, seems to be in the Barclay region, and at the Ralston or McIntyre mines, and a smaller quantity at Renovo, on the Philadelphia & Erie Railroad.

Ligonier Valley extends, under other names, far into West Virginia, with precisely the same geological features, with a similar high, narrow hill in its centre, containing a long, narrow field of the Pittsburg seam of coal running through it. (*See* page 281.)

Sub-conglomerate Coals of the First and Second Basins.—In the southwest end of the first and second basins in Pennsylvania, we see the sub-conglomerate coals beginning to develop themselves. Amid the abundance of coal-seams of larger size and better quality, they are here only of consequence as they serve to throw light upon those of the same age and geological position in Southwestern Virginia, Southeastern Kentucky, and in Tennessee, where they are more strongly developed in number and thickness, and are of great consequence, being the only coals found in many localities in the latter two States. These are a lesser group of coal-rocks, reported by Rogers, lower in the geological series than the great conglomerate which is usually regarded as the base of the pro-

ductive coal-measures. They are found on both sides of Laurel Hill, the boundary-line between Somerset and Fayette Counties, and consequently in the first and second basins. They first assume a notable importance in Turkey Foot Township, in Somerset County, but they expand to greater thickness in the second basin along Indian Creek in the Ligonier Valley trough on the west side of Laurel Hill. These are an earlier-formed carboniferous strata, having no connection with the main body of the coal-measures, but holding a position corresponding to the upper layers of Rogers's formation XI., or Red Shale, and the lower rocks of his formation XII., or Conglomerate. West of the Youghiogheny River, these interpolated coal-strata contain a seam of excellent coal four feet in thickness. It is entirely below the coarse rocks of XII., or the great conglomerate, and 20 feet below the band of iron-ore which usually marks the common limit of this formation, and the red shale or formation XI. The ore here occupies a brown shale, so that it may be considered as appertaining to the coal-measures, which thus form as it were a subordinate part of the underlying red-shale formation.

The reader will hereafter notice the gradual development of these sub-conglomerate coals in a southwest direction. They also appear in Mercer county along the northwest margin of the coal-field on the line between Pennsylvania and Ohio, and on the eastern and southwestern margin of the Illinois coal-field in Western Indiana and Southern Illinois.

The Third or Blossburg Coal-Basin.—Blossburg, Antrim, Cameron, Wistar Mountain, Bennett's Branch, etc.

The third coal-basin in the north is that of Blossburg, in Tioga County. Of this coal-region on the head-waters of the Tioga River, a special account is elsewhere given in this volume. The Blossburg is the only very productive region in this basin. The synclinal or centre of the basin runs westwardly through the Fall Brook, Morris Run, and Blossburg Companies' mines, in Tioga County. The same basin continues westward over Babb's Creek and Wilson's Creek, through a fine coal-field south of Wellsboro on Wilson's Creek, where the Fall Brook Coal Company have opened new mines at Antrim.

(*See* page 124 to page 161, as to these localities.) Thence its general course is southwestward to the Sinnemahoning River, which it crosses 10 miles above its mouth. In an extensive wilderness country like this it is impossible, says Rogers, to pronounce with positiveness upon the existence or non-existence of coal in a basin where a slight dip may bring in unperceived the lower part of the coal-measures. This same synclinal axis No. III., marking the middle of the third basin, also crosses Bennett's Branch about 10 miles above its mouth, thence following the course of that stream. In this basin on the Philadelphia & Erie Railroad are situated the Wistar Mountain Company's coal-works, 67 miles from Williamsport, 267 from Philadelphia, and 183 from Erie; also the Cameron coal-mines, 97 miles west of Williamsport. The centre line of the third basin follows along the general course of Bennett's Branch in a southwesterly direction through part of Cameron and Elk Counties, the western part of Clearfield County passing Luthersburg. In that direction it merges into the general basin of the western counties of the State, of the coal of which a general account will be given as it is displayed along the valley of the Alleghany River.

As the Philadelphia & Erie Railroad leaves the West Branch, and passes up the Driftwood Branch, this has been a secluded, inaccessible region. It is one of our vast, undeveloped parts of the country full of coal, but as yet with nothing entitling it to much space in these pages. A railroad up Bennett's Branch is now (1872) in progress, which will bring to light some of the buried treasures of this wild region. Near Caledonia, in the south part of Elk County, a seam of coal is described by Rogers, without any slate, measuring five feet two inches thick; and the country will be found to be rich in coal, limestone, and iron-ore, for many miles southwest of that place, up Bennett's Branch.

"From Bennett's Branch Intersection with the Philadelphia & Erie Railroad, to the Alleghany Valley Railroad at the mouth of Red Bank, is 92 miles. One of the tunnels, namely, that at the Boon Mountain summit, will be 2,000 feet long, and about 200 feet below the level of the summit, and is 1,400 feet above tide—more than 700 feet lower than the summit of

the main line of the Pennsylvania road at its tunnel above Altoona.

"The line of this Low Grade road is an extraordinary one. Ten years ago no one would have supposed it possible to get a line across the Alleghany Mountain, anywhere, with a summit only 1,400 feet above tide. Still less could any one, familiar with the topography of Western Pennsylvania, have anticipated that a line could be got, connecting Harrisburg with Pittsburg, which should have a maximum grade of only 18 feet per mile, to within four miles of such a summit—a grade of only 37 feet for those four miles—and a maximum descending grade, thence to the Alleghany River, of only 14 feet to the mile. The average grade of the seventy-odd miles, from the summit to the Alleghany River, is only a little over eight feet to the mile; but a somewhat higher maximum is necessitated by the variable rate of water-fall."

Farther southwest, the eastern boundary of the third basin is the Chestnut Ridge, before described as the northwest boundary of the second basin. But in this southwestern district of Pennsylvania the lower coal-measures and the division of the region into basins lose their practical importance. All the lower coals which prevail farther north become attenuated and disappear by the dipping of the rocks in a southward direction, and the basins also disappear. Next above come in the Barren Measures, 400 or 500 feet thick; and next above these the upper coal-measures, to be hereafter described, first or lowest among which is the important Pittsburg bed. The whole country and the whole market accessible from this region are supplied from this coal-seam. For all the purposes of the present generation and many generations to come, for hundreds of years, this Pittsburg bed is and will be the all-important one of this large section of country, covering as it does the southwest corner of Pennsylvania, the "Pan-handle," and other large portions of West Virginia, and a large tract in Southeastern Ohio, in all some 14,000 square miles. It may be highly important for the geological student to follow these lower coal-seams in imagination, as they no doubt run continuously under this whole territory, in itself a good-sized State, and to pry into them as they peep out in deep river valleys. It is well enough for the

farmer who lives on the hills of Greene and Washington Counties, Pennsylvania, on the upper Barren Measures, 1,200 feet above the Pittsburg seam, to talk at his fireside of the stores of coal he owns within the 2,500 feet in depth of productive and barren coal-measures below his feet, but for present practical purposes the upper accessible seams alone are important. The others are merely objects of geological interest, or they may serve as a basis of calculation by the political economist as to the future riches and resources of our people.

Fourth or St. Mary's Basin, Cowanesque, St. Mary's, Shawmut, Toby's Creek, Kiskiminetas.

Synclinal Axis No. 4, or the centre line of the fourth St. Mary's and Toby's Creek coal-basin, crosses the Tioga River and the Tioga Railroad, in the State of New York, two or three miles north of the State line, as displayed in the lower rocks, and runs up the valley of the Cowanesque, in Tioga County, a little south of westward, where there is a thin coal-seam in one locality; thence up West Creek, and southwestward across Potter County. It crosses the Philadelphia & Erie Railroad, on the Driftwood, three miles above Emporium, and perhaps ten miles above axis No. 3. In this fourth basin are several coal-works on the Philadelphia & Erie Railroad, viz., those of the St. Mary's Coal Company, three-fourths of a mile east of St. Mary's village; five miles farther west a branch railroad leads off to the Kersey Coal Company's mines, 3½ miles, and those of the Daguscahonda Coal Company, four miles from the Junction; and about a mile east of Ridgeway is the junction of the abandoned Shawmut Railroad, 16 miles long, which leads off southward to the mines of that company on Toby's Creek. All of these and some others which have been opened are in the fourth coal-basin, the centre line of which continues southwestward through Elk and Jefferson Counties, near Kersey, between the Clarion River and Toby's Creek, the line coinciding with the general course of Toby's Creek. Crossing Jefferson County diagonally, it runs seven miles east of Kittanning in Armstrong County, and dies away on the Kiskiminetas, 2½ miles from its mouth.

In the central part of Jefferson County, in the fourth basin, is a fine coal-region in the Reynoldsville country, but far from

market, and, being without a railroad, quite undeveloped. Prof. Lesley says it is a magnificent coal-region of great length and breadth, holding all the beds of the lower coal-measures, two at least of which attain a thickness of 11 and 12 feet, rivalling in quality, size, and extent of area, the upper coal-measures of Westmoreland County, southeast of Pittsburg.

The new Bennett's Branch Railroad, already mentioned, connecting the Philadelphia & Erie Railroad with the Alleghany Valley Railroad, will run across this fourth and the third basin, through a region affording a great abundance of coal in seams of unusual size.

Fifth Coal-Basin, Coudersport, Ridgeway, and Red Bank.

The centre line of the fifth basin passes about five miles to the north of Coudersport in Potter County; it runs south of Smethport in McKean County, near Ridgeway in Elk County, and Brookville in Jefferson County. Along the Red Bank Creek in this county, and which is the line between Clarion and Armstrong, this basin is fruitful in coals, the Brookville, Clarion, and Kittanning seams, each at least three feet thick, and arching over into both the fourth and sixth basins. Tracing them farther south, as we shall see, along the Alleghany River, they sink under the Barren Measures and upper coal-measures. The fifth coal-seam in the ascending order, where it occurs about 12 miles east of Brookville in Jefferson County, measures between eight and nine feet. The seventh bed is 10 feet thick between the Red Bank and Mahoning, on the road from Kittanning to Brookville.[1]

Sixth Coal-Basin, Northwestern Pennsylvania.

This is the last trough of our Western Pennsylvania coal-formation, counting northwestward from the Alleghany Mountain. On the northwest it is definitely limited by a belt of country composed of the great coal conglomerate which ranges to the southwest out of Warren County, through Venango, into Mercer. On the southeast it is bounded by a well-marked anticlinal axis passing from near Smethport in an almost straight line toward Pittsburg. It is a large basin, and has grand yet simple features of stratification, the limestones and many of the coal-seams being continuous over very extensive areas, though the

[1] *See* Supplement on page 677.

individual beds frequently change much their thickness and external aspects. The included sandstones, slates, and other mechanically formed rocks, display incessant variations of thickness and composition. Thus two seams of coal, in some places separated by 60 feet of strata, will at other points be within 20 feet of each other, the stratification from these causes having little resemblance to the series of coal-rocks farther east.

There are 700 or 800 feet of coal-measures which occupy this trough north of the Ohio River, with eight widely-distributed coal-seams, besides several smaller local ones. Designated from the lowest upward, the four lowest included between the first and second thick sandstones, and which are developed chiefly in Mercer, Venango, and Warren, are neither as continuous nor for the most part as thick as the beds above them. One, at Mercer and Sandy Lake, is four to six feet thick. We find with these lower coals in Mercer the lowest bed of limestone anywhere met with in our Western coal-measures, showing the approach to the great limestone regions of the Western States. The upper four coal-seams are much the most continuous and uniformly valuable. The fifth is the main bed at Fallston, Newcastle, Kittanning, Marrinsville, and in Venango County. The seventh is the most important bed on the Alleghany River above Sugar Creek and on the Red Bank, while the eighth is the chief seam at the town of Butler. This last, which is a very valuable bed, accompanies the preceding, though at a greater elevation in the hills in the vicinity of Sugar Creek and Kittanning, and in the neighborhood of Freeport.

A railroad has lately been completed from Jamestown to Franklin, crossing the northern part of Mercer County, and a considerable coal-trade has immediately sprung up for the supply of the oil-regions. The principal points where coal is mined are at Raymilton in Venango, and at Sandy Lake, Stoneboro, and Pardoe, in Mercer County. There were 185,742 tons produced in 1871. As a general view of the coal in the fifth and sixth basins in the descending order of the seams as they are seen on the Alleghany River will hereafter be given, further details, of which many more may be found in Rogers's final report, will be unnecessary, especially as the region has no very large amount of coal-trade except in the block-coal region of Mercer County.

This section of country between the Alleghany River and the Ohio State line, and between the Ohio River and Lake Erie, has a very gentle slope to its rocks. Prof. Lesley reports that the dip of the formations has been found by actual measurement to be but about one-seventh of one degree. North of the coal-region, however, the descent of the streams is very rapid to the level of Lake Erie.

West of the Alleghany River and French Creek a great change is observable in the rocks between the conglomerate and the Tionesta sandstone. This change attains its maximum in the neighborhood of Mercer, where we find the interval to be 100 feet, and to contain four coal-beds, the upper one, the Tionesta coal, being six feet thick, and the others thin, averaging 1½ foot in thickness. Still farther southwest, in the neighborhood of Newcastle, on Beaver River, the Tionesta coal-measures have resumed their former insignificance as productive strata.

The Sharon group is a series of rocks resembling the coal-measures, which makes its appearance beneath the conglomerate 10 or 12 miles northwest of Franklin. Becoming better developed as we trace it south, it is found to consist usually of a single coal-bed from 12 to 18 feet below the base of the conglomerate, generally quite thin and poor, but attaining in the neighborhood of Sharon and Georgetown the thickness of five feet. At intervals of 15 and 20 feet below this bed are found near Mercer two other coal-beds, 1½ and 2½ feet respectively. This group of coal-strata, Prof. Rogers says, is not to be considered as a lower coal-formation, but as merely a part of the lower group of the coal-measures locally developed by increase of the coal-beds, and a proportionate reduction of the pebbly matter of the sandstones. An analogy may be drawn between these and a series holding a similar position at Turkeyfoot, in the extreme southern part of the State.

We will now take a cross section of the northern part of these coal-basins, or a brief general survey from east to west.

The West Branch Coal-Region, on the Philadelphia & Erie Railroad.

This railroad runs across the northern parts of five of the coal-basins, and forms a good line of observation. In going west from Williamsport on the Philadelphia & Erie Rail-

road, coal is first met with at Queen's or Quin's Run, 30 miles west of Williamsport, where the *First Coal-Basin* of Rogers's (Pennsylvania) Geological Survey crosses this railroad. Here the coal-measures are 150 feet thick, with four seams of coal, three of them valuable. In it are the old Farrandsville mines, which were worked many years ago, and the coal from them shipped by the West Branch Canal; also the Eagleton, the McHenry, and Black Heath mines, on an old branch railroad. The coal was semi-bituminous, and of a good quality for steam. These are all things of the past, the works being abandoned. "At Farrandsville a great furnace was erected, and a quarter million of dollars sunk. The iron-ore is a poor nodular stratum in shale, and a six-foot fire-clay bed under the third coal-bed." This is the Tangascootack region, which farther southwest expands over a considerable extent of country. Snowshoe and Phillipsburg mines in Centre County are in this first basin, farther south. *Second Basin.*—The next mines are at Renovo, 52 miles from Williamsport, where, in 1871, 8,564 tons of coal were mined for the railroad company's shops and to coal engines on the road. The mines are two miles northwest of the Philadelphia & Erie Railroad. This is the Barclay and Ralston basin. *The Third*, or *Blossburg Basin*, crosses the Philadelphia & Erie Railroad, taking in the Wistar Mountain coal-mines, 67 miles, and the Cameron mines, 97 miles west of Williamsport, both situated directly on the railroad, the coal being run down inclined planes from the tops of the hills. Neither of them is in operation. This coal is decidedly bituminous, containing 67 to 69 per cent. of carbon, and 26 to 29 of volatile matter. *The Fourth*, or *Cowanesque Coal-Basin*, embraces several coal-works on the Philadelphia & Erie Railroad, viz.: those of Tannerdale, 117 miles from Williamsport, St. Mary's, 119 miles, and Benzinger, also at St. Mary's. The St. Mary's are the most important, they being the only works on the whole road in full operation. They produced 74,056 tons in 1871 for the use of the Philadelphia & Erie Railroad. The Benzinger Coal Company mined 13,652 tons in 1871. Farther west, 125 miles from Williamsport, is a branch railroad, leading to the Kersey Coal Company's mines, 3½ miles, and to those of the Daguscahonda Coal Company, 4 miles. Their production is now very small. One mile east of Ridgeway, or 128 miles from

Williamsport, is the junction of the Shawmut Coal Company's Railroad, 16 miles in length to their mines on Little Toby's Creek, which are not in operation. A large sum of money was here unprofitably invested. In the *Fifth Coal-Basin*, on the Philadelphia & Erie Railroad, are the Wilmarth or Johnsonburg coal-mines, the last going west, being 138 miles from Williamsport. At Kensua, 162 miles from Williamsport, the road passes out of the coal-measures. All the basins are finger-points or detached patches on tops of the highest hills. The Renovo and St. Mary's mines are on the north side of the Philadelphia & Erie Railroad, all the others on the south of it. There are plenty of other coal-lands not yet opened. Nowhere in the State is there such a spectacle of disappointed hopes and of fortunes buried in the bituminous-coal business. Most of these companies have built branch railroads, some of them of considerable length, and also spent large sums for opening and working mines, and for mining-plant, having been stimulated into premature life by the high prices of coal during the late war.

The trouble with these mines is, they have no market at home, it being a very thinly-populated country. If they go west, they encounter up-grades of 116 to 145 feet per mile for nine miles east of Kane. At Erie, the Western terminus of the Philadelphia & Erie Railroad, they meet the block-coal from Sharpsburg, Mercer County, which has only been brought 75 miles, and which is both cheaper and better. If they go east, they meet with Snowshoe, McIntyre, Broad Top, and Anthracite, which have been carried a shorter distance. The completion of the Buffalo & Washington road to Emporium will afford the region a better avenue to that important market.

Lower Coal-Measures on the Alleghany River in the Fifth and Sixth Coal-Basins, in the Descending Order of the Geological Strata.

The two chief rivers which traverse the Western Pennsylvania bituminous-coal-basin, flowing in opposite directions, intersect wholly different strata—the Monongahela and its western tributaries passing through the upper coal-measures and the Alleghany River through the lower. Starting from the marly shales exposed at the water's edge at Pittsburg, and ascending

the Monongahela, we rise into higher and higher layers, and following its western streams into Greene County, we may even reach the uppermost beds of the whole series. Ascending the Alleghany River, on the other hand, we come upon geologically lower and lower rocks emerging successively to view, until in the neighborhood of Franklin and Warren we encounter those that form the bottom of the basin.

Ascending the valley of the Alleghany River to Sharpsburg, four miles from Pittsburg, we there find the hills consist of the same rocks as at Pittsburg, but the Pittsburg coal-seam is found only on the highest knobs; and lower strata of rock than those seen at Pittsburg begin to show themselves in the lowest places. At Fairview, or Sandy Creek, five miles farther up the river, the hills are 350 feet high, and too low for the Pittsburg coal. When we arrive at Tarentum we find still more of the series has vanished. The river hills average 250 feet, while the coal-bed E, Upper Freeport, of the lower coal-measures, has just made its appearance. This is the first or upper workable coal-bed of the lower coal-measures, and is one of the most important and widely extended. It covers an area twice as large as the Pittsburg bed, and affords a remarkably rich, compact, and inflammable coal. It rises about three miles below Tarentum, near which it is mined at an elevation of 30 feet, the bed being six feet thick, and in places seven feet. It can be traced through the eastern part of Armstrong County; it ranges westward through the central parts of Butler County and through portions of Alleghany and Beaver Counties, disappearing ultimately beneath the Ohio River, in conformity with the general southwestern dip of the coal-measures. Near the town of Butler it is four feet thick, holds a high position on the hills, and is extensively wrought. The attentive reader will understand this as the description not of the boundary of the northern outcrop of this fine seam of coal, but where it first appears in the river-bed, and that it dips southward and passes under the barren and the upper coal-measures, and is found also on the higher ground farther north.

It may be observed that, although the general dip is toward the south, it is by no means regular. Thus, below Freeport, at some of the coal-mines, the local dip is up the river, while in fact

the general dip is in the contrary direction, as is shown by the coal cropping out on the north and sinking under the river to the south. At Pittsburg, coal E appears to be from 100 to 150 feet below the river, while at Freeport it has the height of 144 feet above the water. At Kittanning, 44 miles from Pittsburg, it is still higher, 370 feet above the river, rising farther north to the tops of the most elevated hills. At Kittanning we see at an elevation of 100 feet the fossiliferous limestone and other rocks which were far beneath the river-level at Freeport, and the last remains of the Barren Measures are indicated by the red and variegated shales which cap the highest hills on both sides of the river. The next coal-seam, in the descending order, D, or the lower Freeport, first appears above the level of the Alleghany River, about two miles above Tarentum. At Freeport it is seen at an elevation of 57 feet above the river, or 87 feet below E. This seam is remarkably irregular as regards thickness, measuring in some places four feet, in other places two feet, and at the mouth of the Kiskiminetas a thin layer of soft bituminous shale mixed with coal supplies its place. This coal is remarkable for its irregularity, not only as respects its thickness and local dip, but as regards the nature of the accompanying strata. Beneath this coal D, or lower Freeport, sometimes in contact with it, occurs the Freeport sandstone, 70 feet thick. Above coal E, or upper Freeport, is a thick mass of brown and blackish shales more than 50 feet thick, upon which is the Mahoning sandstone, 75 feet thick.

Returning to the coal-seams, we next in ascending the river find an important seam of coal C, Kittanning or Clarion, which is widely extended and important. It emerges from below the Alleghany River, about five miles above the mouth of the Kiskiminetas. At Kittanning it attains an elevation of six feet above the river, and has been extensively wrought near the base of the hills on both sides of the river, and is 3½ feet thick, but it varies somewhat in thickness like all other seams, and is sometimes five feet thick. This coal-seam may be readily traced on the river-hills between Kittanning and the mouth of the Clarion River; it sinks and disappears beneath the country on both sides, and reaches the day on the Beaver River and its branches, on Red Bank Creek, on Buffalo Creek, and elsewhere. It

is the Cannel coal-seam of the Alleghany River Valley, also at Darlington, near the Ohio line, and at Peytona in West Virginia. Below coal C is a bed of brown and black shale with layers of sandstone 25 feet thick, and then the buhr-stone and brown silicious iron-ore, some portions being analogous to the burrstone of France, and other parts a hard, grayish and yellowish schist or flint.

The next seam of coal is B, 71 feet below coal C. This important coal slowly rises above the base of the river-hills above Kittanning. Over it lie three layers of coal b, each about one foot, and one of them sometimes twenty inches or two feet thick, separated from each other by shale. Rejecting these, the principal seam measures 3½ feet thick. East of the Alleghany and south of the Clarion River it is opened in many places. It can also be traced east of the river through Venango and Clarion Counties. In the vicinity of the town of Mercer it is three feet thick. Traced to the southwest it sinks beneath the bed of the Ohio. This is the Towanda, Ralston, Blossburg, Queen's Run, Barnet (Broad Top), the large Tangascootack, and the great bed near the bottom of the coal-measures above Johnstown, and is found and wrought in many other places throughout the State.

Forty feet below coal B is the seam A, the lowest workable bed along the Alleghany River. Although numerous thin bands of coal occur in the slate beneath, they are not of sufficient size to work. Six miles east of Franklin it lies on the summit of the hills. It is a thin and everywhere generally a worthless seam, composed of two parts of about one foot thick of coal, separated by heavy slates. It may be found of a good size and valuable quality in some localities. It seems to attain its greatest size at Lockport and about Phillipsburg. It retains the characteristics described above also in the anthracite regions (*see* p. 49). The centre of the fourth basin runs east of the valley of the Alleghany River, seven miles east of Kittanning and 2½ miles east of the mouth of the Kiskiminetas opposite Freeport.

At Foster Station, 115 miles above Pittsburg and eight miles below Franklin, a small seam about 2 or 2½ feet thick has been opened, on the west side of the Alleghany River, near the top of the hill, which is apparently the last appearance of coal in

this quarter in ascending the river. Farther north the mountain sandstone, as it is here called, may be seen capping the tops of the hills, the base of the coal-measures, but without coal. Farther east the six finger-points of basins carry lines of smaller coal-fields nearly to the New York line. The localities where coal-works are in operation on the Alleghany Valley Railroad, in 1871, are all south of the Clarion River, viz.: Monterey, 78 miles from Pittsburg, Hillsville, 75, Catfish, 71 miles, this being the most extensive, producing 350 tons per day. All of them are on seam C, which is here 4½ feet thick at its best exposures. North of the Clarion, on this river, it does not exceed three feet. At Brady's Bend a large quantity of coal is mined and used in the great iron-works there. Also at the Monticello, Mahoning, Pine Creek, and Stewartson furnaces in Armstrong County. At Sandy Creek, nine miles above Pittsburg, a larger coal business is done, in H, or the Pittsburg seam.

Cannel-Coal.—Previous to the discovery of petroleum in large quantities in Northwestern Pennsylvania, oil was distilled from cannel-coal mined from coal-seam C, along the Alleghany River. A great number of very expensive establishments were erected, and a large business was done. But the discovery of our wonderful deposits of petroleum in Crawford and Venango Counties, about the year 1860, dispensed with all this machinery for distillation, and continued to employ so much of it only as was required for refining the oil obtained from the wells.

The mines which had been opened and the labor of the coal-miner became unnecessary. It is a beautiful grate-coal, but there is now no important business done in mining cannel-coal, for which there is no large demand in the market. Coal is chiefly wanted for iron-making and for steam purposes. Cannel-coal contains more illuminating gas than common bituminous coal, and sometimes a limited quantity of it is used to improve the quality of the gas. But, in the manufacture of gas, fuel is required, and cannel-coal produces but little coke. The common bituminous coal of the Pittsburg seam cannot be surpassed, and is everywhere used for gas-making purposes. The supply for the eastern market comes from the eastern margin of the coal-field of the upper coal-measures H, or the Pittsburg bed in Westmoreland County. The locality is in the vicinity of the

stations called Irwin, Penn, Shafton, etc., whence it is transported on the Pennsylvania Railroad about 330 miles to Philadelphia. The Westmoreland Coal Company are the principal operators in this coal. The Alleghany Valley region is in our day of quite secondary importance. It is geologically interesting as showing the structure of the coal-region and the series of the lower coals, which alone are found in so large a part of the State; but it is not where the coal of the western country is mined. The Alleghany River coal-trade, which was 355,586 tons in 1870, is as nothing compared to that of the Monongahela and Youghiogheny Rivers region, and that along the railroads leading in all directions from Pittsburg through the upper coal-measures, which produce ten times more. But, before proceeding to the Pittsburg region, there is a very important one demanding attention in the northwestern part of Pennsylvania.

Chenango Valley, or Mercer County Block-Coal.

A line drawn in a west-southwest direction from Kensua, on the Alleghany River, near the west line of McKean County, through Sandy Lake, Mercer County, to Youngstown, Ohio, will define with tolerable accuracy the northwest limit or outcrop of the lowest coal of the sixth and last basin of the great bituminous coal-region. But within this boundary every valley crossing this line cuts down through the coal into the lower rocks. The conglomerate, however, extends about 10 miles farther northwest. Beneath the conglomerate we find a small group of coal-measures, which comes in under the great conglomerate in the country between French Creek and the Ohio line, and containing a valuable seam. This is the Sharon coal, in Mercer County. It is a species of semi-cannel-coal with a slaty structure, and a dull, jet-black lustre, with a thickness of from three to four feet.

It seems an extraordinary circumstance that the most important coal-region in Northwestern Pennsylvania and Eastern Ohio, as respects the present production and the quality of its coal, should be almost outside of what was regarded as the coal-region, and below the coal-measures. The so-called splint-seam, producing block-coal, belongs to a group of coal-strata which, although appertaining to the true coal-formation, were long ago recognized as being beneath the main body of the conglomerate.* Though the bed is frequently a mixture of coal

and slate, as its name implies, it produces the most valuable coal in the United States, and it embraces one and sometimes two important beds.

One of the most important uses to which mineral coal has been applied is the smelting of iron or the manufacture of pig- or cast-iron from the ore. When bituminous coal is used for this purpose, it is usually necessary that it be first coked, which is not only attended with labor and expense, but with the loss of much of the heating power of the coal. There is no bituminous coal in Pennsylvania that can be used in a raw state for smelting iron, except the splint or block-coal, as it is commonly called, of this region close to the Ohio line in Mercer County, on the Pittsburg & Erie Railroad, and the Beaver & Erie Canal. The qualities required for this purpose are, sufficient hardness in the mechanical structure of the coal to bear the pressure of a charge and the high temperature required in the blast furnace, the absence of all the melting or caking property, which would stop the draught in the stack, freedom from sulphur, in order to produce iron of a good quality, and sufficient heating power. At this farthest northwestern outcrop of the great Alleghany coal-basin, the requisite conditions were present for producing just the quality or species of coal best adapted to this purpose. The seams of this lower coal are very irregular, being found in small basins appearing to have been deposited upon an uneven floor. The beds vary from two to five feet, and the basins from a few acres to 500 acres. The same coal on the Ohio side is subject to the same distortions, forming basin-shaped cavities that sometimes sink 20 feet in a less number of rods. In the larger basins the central part has a good thickness of coal, four to five feet, thinning out toward the edges. There were nearly 500,000 tons of block-coal produced in Mercer County in 1871, and twenty-three blast-furnaces in the district above mentioned were running on this coal in that year, with others in the course of construction. There are about the same number of furnaces on the Ohio side of the line.

The principal locality where this peculiar coal is produced is along the line of a small branch of the Erie & Pittsburg

* So reported by Rogers; but this block-coal seam A, in the adjoining district in Ohio, is certainly above the conglomerate, by Dr. Newberry's reports.

Railroad at Sharpsburg, 75 miles south of Erie. The mines are in Hickory Township, and in the vicinity of Sharon, Wheatland, and Middlesex, in the southwestern part of Mercer County, and the area is quite limited. Some further notices of the splint or block coal will be found in the chapter on Ohio, and in that on Indiana. The Brier-Hill and Youngstown (Ohio) district is an extension of that of Mercer County, Pennsylvania, the several places mentioned being but a few miles distant from each other. However it may be accounted for, this block-coal appears always to occur in islands, or along the borders of, and as yet it has not been found extending under, the larger coal-fields.

2. THE UPPER COAL-MEASURES.

The bituminous coal-measures of this State constitute, according to Prof. Rogers's reports, but one group of sandstones, limestones, shales, and coal-seams, not susceptible of any natural subdivision. But, as it is a very extensive and complicated system of rocks, he, for convenience, divided it into the upper and lower series, each surmounted by a series of shales and sandstones comparatively barren of coal. But these divisions are only convenient aids to the memory, or for descriptive purposes, for, as he remarks, "the mineral deposits of the earth, unlike its vegetable and animal inhabitants, follow no very constant types, undergoing, though sometimes very gradually, incessant changes both of composition and external features." The Ohio geologists, on their first survey in 1838, in examining the strata near our State line, were unable to arrange them according to Prof. Rogers's general classification, as they found coal-beds in the barren sandstone series. Yet that series is comparatively barren of good coal, and the name serves to designate it just as a portrait reminds us of the original, although the prominent features are somewhat exaggerated.

The upper coal-measures do not extend beyond the limits of Alleghany, Washington, and Greene Counties, the southern townships of Beaver and Armstrong, the southwestern ones of Indiana, and all those sections of Westmoreland and Fayette lying northwest of a line near the base of the Chestnut Ridge and some detached patches in Somerset County. All other

parts of the general bituminous coal-field are occupied by the lower coal-measures. This is therefore a proper place to introduce the numerous details of the strata composing the whole coal series:

ROGERS'S SYSTEM OF THE COAL-ROCKS OF PENNSYLVANIA, IN THE ASCENDING ORDER, FROM MERCER TO GREENE COUNTIES.

No.		Feet.
	ALLEGHANY RIVER.	
	I. Lower Coal-Measures.	
1	Conglomerate and Tionesta Sandstone	50 to 60
2	Slate and Shale	5 " 15
3	*Coal A, Brookville*	1 " 2
4	Slate and Shale	25
5	*Coal B, Clarion, Blossburg, etc.*	3 " 4
6	Slate and Shale	30
7	Ferriferous Limestone	15
8	*Buhrstone and Iron Ore*	½ " 6
9	Shale and Sandstone	30
10	*Coal C, Kittanning*	3 " 4
11	Slate and Shale	75
12	Freeport, Dunbar, or Contorted Sandstone	50 " 60
13	*Coal D, Lower Freeport*	3
14	Shale and Sandstone	30 " 40
15	Limestone	4 " 7
16	Fire-clay and Shale	1 " 10
17	*Coal E, Upper Freeport*	3 " 6
	Total feet....... 392	392
	PITTSBURG REGION.	
	II. Barren Measures.	
18	Shale	50
19	Mahoning Sandstone	75
20	*Coal F, Elk Lick Coal*	1 to 2
21	Thick Shale	
22	Slaty Sandstone	30
23	Red and Blue Shale, Pittsburg	20
24	*Coal G*	1
25	Limestone	2
26	Olive Slate and Buff Shale	100
27	Ligonier Sandstone	70
28	Red Marly Shale	12
29	Shale and Slaty Sandstone	10
30	Limestone	3
31	Red and Blue Shales	4
32	Buff Shales	18
33	Yellow and Purple Shale	10
34	Limestone	2
35	Red and Yellow Shale	12
36	Limestone	3 " 5
37	Shale and Sandstone	30
38	Limestone	25
	Total feet....... 873	481
	MONONGAHELA RIVER.	
	III. Upp'r Coal Measures.	
39	*Coal H, Pittsburg Seam*	5 to 8
40	Brown Shale	30
41	Gray Slaty Sandstone	25
42	Shale	20
43	Limestone (the best)	16
44	Black Calcareous Slate, sometimes 2½ feet coal	8
45	Slaty Sandstone	18
46	Black Slate	5
47	Limestone	18

No.		Feet.
	MONONGAHELA RIVER *Continued.*	
48	Shale	10
49	Flaggy Sandstone	20
50	Shale	10
51	Upper Limestone	8
52	Sandstone and Shale	35
53	Soft Shale	5
54	*Coal I, Waynesburg*	6
	Total feet..... 1,115	242
	WASHINGTON AND GREENE COUNTIES.	
	IV. Upper Barren Group.	
55	Yellow and Brown Shale	10
56	Gray and Brown Sandstone	35
57	Blue Friable Shale	7
58	*Coal*	2
59	Soft Blue Shale	3
60	Limestone	4
61	Soft Blue Shale	4
62	Limestone, three layers	4
63	Blue and Yellow Shale	10
64	Sandstone, in three layers	20
65	Brown and Blue Shale	10
66	*Coal*	1
67	Brown and Blue Shale	4
68	Sandstone	20
69	*Coal*	1
70	Buff Shale	20
71	Limestone	8½
72	Buff Shale	50
73	Gray Micaceous Sandstone	11 to 14
74	Buff Shale	17 " 20
75	Gray Micaceous Sandstone	14
76	Yellow Micaceous Shale	15
77	Shales and Sandstones	62
78	Flaggy Sandstones	18
79	Blue and Buff Shales (thin)	
80	*Coal, ten inches*	1
81	Blue Shales and Sandstones	42
82	Limestone	3
83	Thin Bedded Sandstone	15 " 25
84	Shale and Limestone	10
85	*Coal*	1
86	Dark Gray Shale	18
87	Limestone	2
88	Shale and Laminated Sandstone	15
89	Limestone	3
90	*Coal, ten inches*	1
91	Limestone	½
92	Gray Sandstone and Shale	42
93	Yellow, Blue, and Brown Shale	27
94	Limestone (thin)	
95	Green Micaceous Sandst'ne	44
96	Dark Gray Sandstone	18
97	Blue, Buff, and Olive Shale	56
98	Limestone	5
99	Dark Calcareous Slate	5
100	Gray and Buff Sandstone	110
101	Blank	200
	Total feet......2,089	974

The Pittsburg Seam in Pennsylvania.—The following are the limits or boundaries of the Pittsburg coal, or the upper productive group which, in the ascending order, commences with the Pittsburg seam. It crosses the southern line of Pennsylvania near the southwest corner of Fayette County, a little east of where the Monongahela River crosses it, and pursues a very nearly straight northeast course close along the base of Chestnut Ridge to Blairsville. But this is only a long, narrow fork of this coal-basin, three or four miles wide, cut off by the Westmoreland and Fayette anticlinal axis, with Uniontown, Connellsville, Youngstown, and Blairsville, in its centre. Greensburg stands on an island of the Pittsburg coal-seam of a few square miles, bounded on the west by the Saltzburg and Brownville axis, and there is another similar detached field on each side of the Conemaugh at Saltzburg. These gave rise to a coal-trade, in 1871, of 142,681 tons on the Western Pennsylvania Railroad. Returning to the main body of the Pittsburg coal-field, to a point six miles southwest of Uniontown, the outcrop pursuing a north-northwest course, crosses the Monongahela River at Perryopolis, thence to Adamsburg, and, including the northwest corner of Westmoreland County and the southern two-thirds of Alleghany County, the northern line runs westward across the Alleghany River below Tarentum, and the Ohio River near Little Sewickly Creek in Alleghany County, and, bending a little southward, touching the southern part of Beaver County, it runs over the State line and recrosses the Ohio River a little north of Steubenville, Ohio. Its boundaries in Ohio and Western Virginia are given in the accounts of the coal-regions of those States.

"The Pittsburg coal or main upper seam of the lower limit of the upper coal-measures evidently underlies every part of the large area thus defined, and this area, in Pennsylvania, Ohio, and West Virginia together, appears to amount to about 14,000 square miles, of itself a very noble coal-field. Of course, each of the overlying coal-beds of this upper group possesses successively a less and less extent. It manifests, in its broad extent, and in the singular persistency of its characters and subdivisions, the wonderful uniformity of all the physical conditions under which its materials were accumulated. This prodigious floor

of coal does not hold everywhere the thickness it possesses in Southwestern Pennsylvania, but undergoes a very gradual progressive reduction of size as it advances south and southwest; it declines indeed to a thickness of little more than three feet near the south end of the coal-basin which it occupies."

The size, constitution, quality, and accompaniments of the Pittsburg bed, so called on account of its being so extensively mined in the vicinity of that city, are thus described by J. P. Lesley: "Its size throughout the major part of its extent is eight feet, gradually increasing eastward in Ligonier Valley, in Fayette County, Pennsylvania, to nine; in Elk Lick Township, Somerset County, to 11; and in the Cumberland (Maryland) region, to 14 feet. Its constitution is everywhere that of a double bed, two or three feet of bony coal above, and five to ten feet of rich, solid, pure bituminous coal below, yielding 40 to 45 cubic feet of gas to ten pounds of coal, where it is best known, and very free from sulphur, although, strangely enough, both its roof and floor are full of pyrites. As to its accompaniments, above it are massive limestones, and the workable coal-beds of the upper series of which it forms the base; and below it are the Barren Measures, which separate it from the lower series of coal-beds resting upon the conglomerate, which is 600 to 700 feet below the Pittsburg seam."

The Pittsburg seam is thus described by H. D. Rogers, in his report for 1839. It is probably the most important and extensively accessible seam of coal in our western coal-measures. It spreads uninterruptedly over the whole valley of the Monongahela, from the base of the Chestnut Ridge to the western boundary of the State, and west of the Ohio River. The critical investigation of this bed, and its accompanying strata, is highly interesting, and leads to some curious and striking geological inferences. The uniform disposition of vegetable matter over so extensive a tract of ocean is, in itself, a geological fact richly worthy of consideration by any intelligent mind, while the regularity with which it maintains its characteristic features is not less remarkable, or less likely to inspire us with curiosity to know more of the mighty operations of Nature, during the earlier conditions of the earth's ever-changing surface.

It consists of three parts: first, the main breast of coal; above this a layer of clay; and over this a bed of coal, forming the roof. The former of these rests upon the limestone, from which it is separated, generally, by a few inches of blue clay or decomposed shale. The seam is from five and a half to eight feet in thickness, affording coal of the purest and best kind. In the neighborhood of Pittsburg, the lower part of this mass, for about one foot in depth, abounds in thin seams of pyritous shale, and is hence rejected by the miners. Above this part of the seam, there is the stratum of blue or black clay-shale, dividing it from the coal-roof. It is hard and compact when first dug out, but on exposure to the atmosphere crumbles down into a soft clay. It is generally free from gritty particles; and, with a similar layer in the coal next the roof, it has been advantageously used in the manufacture of fire-bricks. Above it is the roof-coal, consisting of a bed of coal with shale intermixed in numerous thin layers. Toward the bottom this is a band of true coal, from one to two feet thick; the higher layers are generally thin. The coal in this part of the seam is, in itself, of good quality, but the expense of separating it from the accompanying slate is generally too great to justify the attempt. Hence the miners, along the Monongahela, content themselves with extracting the lower division, leaving the remainder to form the roof of their drifts. In Alleghany County the main breast varies from five to six feet in thickness; but, as we ascend the Monongahela and approach near the Chestnut Ridge, it enlarges much, yielding in some places from eight to nine and a half feet of pure and compact coal. The quantity of pyrites, in the clay and shale accompanying the coal, is very considerable; these layers readily crumble, and when exposed to the atmosphere are generally covered with *copperas*, produced by the chemical action upon the sulphuret of iron.

Seventy-five feet above the Pittsburg seam occurs the great limestone, the most extensive and valuable calcareous deposit in the valley of the Monongahela, or anywhere else in the western counties of the State; for the limestone beneath the Pittsburg coal is comparatively thin and of little importance as a source of lime for masonry or agriculture. About seventy-five feet above this limestone deposit is found

The Waynesburg Coal-Seam,

which, for importance, ranks next to the Pittsburg bed everywhere throughout the southern part of the valley of the Monongahela. Although affording, generally, coal of very excellent quality, it is not worked except in Greene County, and the adjacent parts of Washington County. Over the northern portion of the district it has been removed from the surface by denudation. It is about six feet thick, and is divided near its centre by a band of soft shale, which varies much in thickness. The lower part of the seam affords the best coal, and, with care in extracting the slate, it forms an excellent fuel; the upper part is less pure, and has a slaty structure, breaking into pieces of a prismatic shape. The adjacent slate is very full of pyrites, frequently containing large nodules of that mineral, by the decomposition of which copperas is abundantly produced, forming a coating on the surface of the coal, and the included shale.

This seam of coal is met with in the high hills in the neighborhood of Brownsville (*see* plate on page 224), and also about two miles east of Waynesburg, in Greene County. Here it is seen in the bed of South Ten-mile Creek, emerging from beneath the elevated ridge of country which extends through the centre of that county, and forms the high land which separates the tributaries of the Ohio River from those creeks which empty into the Monongahela. Passing beneath this table-land it is again met with, as it reappears on the western side of the county along the south fork of Wheeling Creek, a few miles from the State line. From the vicinity of Waynesburg it spreads through the eastern part of Greene County, where it is worked extensively in Jefferson and Cumberland Townships. This bed of coal will, when the country becomes more thickly settled and better cleared, be considered a highly-valuable deposit, and will then be found to have a much wider range than is now attributed to it.

Structure of the Upper Coal-Measures.

Although the great flexures which form the six basins of the lower coal-measures do not extend into the southwestern

part of the State where the upper coal-measures are found, yet this important part of the field has some features in its structure worthy of notice as they affect the dip and range of the Pittsburg seam of coal. As a rule, this bed observes a nearly horizontal position, dipping very slightly to the southwest, with undulations running through it from northeast to southwest, parallel to the axis of the Chestnut Ridge, and affording a miniature representation of what has taken place on a large scale along the southeastern side of the whole coal-field near the Alleghany Mountain.

Between the Chestnut Ridge and the Monongahela River there are two parallel anticlinal axes which throw these western or upper coal-measures into three closely-united troughs. The most eastern line of elevation, which might be called the Westmoreland and Fayette axis, crosses the Conemaugh about two miles west of Blairsville, and ranges southwestward to the Virginia line, preserving an average distance of about five miles from the western base of the mountain. It may be seen about four miles east of Greensburg, in Westmoreland County; farther southwest it may be detected a few miles west of Mount Pleasant and Connellsville, also three miles west of Uniontown, Fayette County, and as far south as in the vicinity of Mount Morris, in Greene County, at the West Virginia line. Throughout the whole distance from its northern end to a point about six miles southwest of Uniontown, the upper beds of coal have been entirely swept away from its summit over an extensive tract of country. But from the point described to the State line the anticlinal arch begins to subside, allowing the upper coal-measures to gently sweep over it.

The Connellsville Coke-Region.

A few miles east of the line above described the coal resumes its western dip, and is found regularly cropping out along the base of Chestnut Ridge in a long, narrow peninsula or trough of the Pittsburg seam throughout its whole length, from north of Blairsville to Uniontown, particularly near Youngmanstown, Mount Pleasant, and the important locality Connellsville. Prof. Rogers reports briefly the strata commencing with the bot-

tom of the coal-measures which repose on the western flank of the mountain, and taking in the whole series as high as about 200 feet above the Pittsburg seam. This thickness includes several coal-seams lying above the great Pittsburg or Connellsville bed which occurs in the highest hills of the middle or deepest part of the trough which is next west of Chestnut Ridge.

Throughout this first trough or basin west of the Chestnut Ridge, which may now be properly called the Connellsville basin, the superb Pittsburg bed, the great coke-seam, occupies the middle of the field, and appears along two parallel lines of outcrop which range from half a mile to two and a half miles asunder, that being the width of the basin. In some neighborhoods the bed as it dips into the middle of the trough descends to a considerable depth below the lowest water-course; while in other places the bottom of the basin which it forms does not reach the water-level. This is the now-celebrated Connellsville region. As there seems to be an erroneous impression prevailing in the western part of the State that the Connellsville coke-bed is one of those higher in the series than the Pittsburg seam, the following extracts are given from a report by J. P. Lesley, on the geology of the Dunbar Furnace lands in that vicinity. This popular mistake has no doubt arisen from the unusual thickness of the Barren Measures in this basin, which are about 400 feet thicker than in those immediately east of it, but the stratigraphical evidence is conclusive as to the identity of the Pittsburg with the Connellsville coke-seam.

"Chestnut Ridge, where the Youghiogheny River breaks through it just above Connellsville, is a barrow-shaped mountain, with a flat top, so far as the numerous deep ravines have left a top to it, about 2,000 feet above the sea, and 1,200 feet above the river-bed. Connellsville is about 200 feet above Pittsburg. Chestnut Ridge is an anticlinal mountain, commencing more than 100 miles to the north of Connellsville, in Clearfield County, and running on southward into Virginia. The coal-measures of the Ligonier Valley basin to the east of it arch over the mountain, descend its western slope, and plunge deep beneath the country of the Monongahela. The mountain-ridge is composed of three or four massive sand-rocks, the edges

of which form magnificent ranges of cliffs along the sides and slopes of the river-gorge, and the numerous lesser gorges of Dunbar Creek and its tributary streams.

"To speak intelligently of these formations and the coal-beds which lie between them, I will call them (beginning at the top) the Ligonier sandstone, the Mahoning sandstone, and the Dunbar sandstone, which forms the great cliffs, and No. XII. sandstone or conglomerate.[1] The relationship of these great beds of sand-rock to those of the Conemaugh and Alleghany country has an important bearing upon the question of the existence of coal-beds in the mountain. The Ligonier sandstone is a great deposit of sand and gravel 50 or 60 feet thick, and about 100 feet below the Pittsburg coal-bed; the Mahoning sandstone is the name usually given to the great deposit at the bottom of the Barren Measures, and from 500 to 700 feet below the Pittsburg coal-bed, the Dunbar cliffs are in the proper place, for the Freeport sandstone, which has an immense range north of the Mahoning and Red Bank Creeks, and the Tionesta sandstone, if it extend so far south as the Youghiogheny, may be too thin to notice, or may be confounded with the masses of sandstone on the slopes below the great cliffs, which represent, no doubt, the great conglomerate or No. XII., the usual base-rocks of the coal-measures.

"The Five-foot coal-bed (E), under the Mahoning sandstone, is opened on both sides of the creek, near water-level, at the furnace, and on the slopes of the hills, at several points of the ascending outcrops of the bed, to a height of over 500 feet. It lies about 100 feet above the Three-foot coal-bed, which lies about the same distance above the Big Bottom ore-bed. The Five-foot coal has been used for farming purposes, and would do very well to roast with, and could be mined cheaply and close to hand.

"But the main dependence of the iron-maker in this region is upon the great Ten-foot vein, or Pittsburg bed (H), five or six hundred feet higher in the measures. This noble coal-bed, which extends in a solid sheet from Connellsville to Wheeling, and from Saltzburg to the Ohio River, and the fragments of which, in the Ligonier Valley, in Somerset County, in the

[1] Nos. 27, 19, 12, and 1, of the general section, on page 211.

Cumberland coal-basin, and on Broad Top, testify to its former existence over a far greater area toward the east, and in Western Kentucky toward the west, is in its prime along the Connellsville road. At Pittsburg it yields but five or six feet of coal, and that too sulphurous to make coke. As it ascends the Monongahela it improves in thickness and quality. Most of the coke now used in Pittsburg comes from this bed opened along the Youghiogheny, the quality of the coal steadily improving up the river, and nothing can be better than Connellsville coke. The bed outcrops along the hills. It is about eleven feet thick, and dips from about one foot in six to one in ten. The miners leave about ten inches of coal, to keep up the slate roof, and take out seven or eight feet of solid coal. The roof is regular, while the floor rises and falls in places, from an inch to a foot, producing swamps. On the rolls the whole thickness of the bed is sometimes only eight feet. A bearing-in slate of about one inch in thickness runs three or four feet above the floor, and a second one, eight inches higher; the coal is mined between the two."

Connellsville coke has become very celebrated not only about Pittsburg but throughout the Western States, where it is extensively used for foundery-purposes in melting pig-iron, selling in competition with Lehigh coal. It is used in blast-furnaces for smelting iron from the ore, and is sometimes mixed with the Western coals. It is also an excellent fuel for locomotive use. Its freedom from sulphur has given this coke the reputation of being the best known. The Pittsburg and Connellsville Railroad is a large transporter of the coal and coke of this region, while a portion of it produced near the mouth of the Youghiogheny finds its way to market by the Monongahela River slackwater navigation.

Connellsville coal weighs 80 pounds to a bushel, and when properly coked a hundred bushels of coal produce 125 bushels of coke, and the coke weighs 40 pounds to a bushel; that is, a given quantity of the coal gains one-quarter in bulk, and loses three-eighths of its weight, or 100 pounds of coal makes 62½ pounds of coke. At the Dunbar Furnace 70 bushels of coke, produced from two gross tons of coal, smelt a ton of pig-iron, but the Pittsburg furnaces use 80 to 85 bushels, the difference

being owing, probably, in part at least, to the kinds of ore and limestone used.

Coal above the Pittsburg Seam in the Connellsville Region.

Prof. Rogers reports the first coal over the Pittsburg seam as very thin in the northern part of the district south of the Conemaugh, but, advancing southward to the Sewickly, it is as much as four and a half feet thick, composed of very good coal, and situated 35 feet above the great seam, only a short space below the large mass of limestone. Farther south it somewhat augments in size, and has been wrought at several places. At Evan's Mill it is five feet thick, and supplies an admirable fuel. Near Uniontown it is 85 feet above the great or Pittsburg seam. Above the great limestone is a seam of coal from 18 inches to three feet, opened at Uniontown, and several other places to the southwest. Higher still in the series two other beds occur; but the next seam of importance lies above these again, being confined to the very highest hills in the middle of the first trough or Connellsville basin. It is opened in several places in Westmoreland and Fayette Counties, and varies from four to six feet in thickness. From the usual high position of the seam in the hills, it is apt to be destitute of a good roof, but, whenever it is sufficiently covered, the quality of the coal is excellent. This is the highest valuable coal-bed of the district, but besides those enumerated there are several lesser seams which are only locally important.

Rogers describes this trough as characterized by the number and importance of its coal-beds toward the bottom of the upper group, based upon the Pittsburg seam, including the Waynesburg series. Where the basin is deepest this group measures 500 feet in vertical thickness, and contains five identified coal-seams, the Pittsburg, the Redstone, the Sewickly, the Uniontown, and the Waynesburg beds, with several not then classified.[1]

No phenomenon in the geology of this region is more remarkable than the great thickness of the Barren Measures in this third basin, which are 600 feet, while in the second

[1] The general section of West Virginia, on page 277, and that of Maryland, on page 252, show the position of these coal-seams in the series.

basin, in Ligonier Valley, not 10 miles east of this locality, they are scarcely 200 feet, and in the Saltzburg division of the first basin from the upper Freeport through the Barren Measures to the Pittsburg seam is but 225 feet.

South of the Youghiogheny at Connellsville, along the central line of that basin, stand isolated knobs of such a height as to appear to be but a little lower than Chestnut Ridge. They evidently consist of shales and sandstones high in the upper series. The summit rocks may be considered as at an elevation of 450 or 500 feet above the plane of the Pittsburg coal-bed. The tops of these hills are in the central line of the basin. The outcrops of several unopened coal-seams were noticed by Prof. Rogers.

The second, or Saltzburg and Brownsville, axis or arch crosses the Conemaugh about four miles above or east of Saltzburg, and extends parallel to the former, preserving a distance of about five miles to the west, until it terminates nearly one mile and a half north of Sewickly Creek. Between this axis and the first or larger one lies the shallow basin or field of the upper coal-measures on which Greensburg is situated. West of this and near the east margin of the great unbroken field of the Pittsburg bed are the extensive coal-works of the Westmoreland Coal Company before referred to, near Irwin Station. In 1871 there were produced in this vicinity 856,065 tons of gas-coal, most of which was sent to market on the Pennsylvania Railroad, and 326,307 tons were used in their locomotives. The Greensburg basin or canoe is about 15 miles long, and its greatest breadth a little less than two miles. South of the Sewickly Creek the second arch flattens away, and its eastern dip gives place at that stream to a western one thrown off from the first and more continuous arch lying east. This second axis is usually indicated by a low belt of hills, the soil of which is much inferior to that in the adjoining troughs. Nearly continuous with this axis, but situated a little to the west of what would be its regular prolongation, there rises farther to the southwest another low anticlinal arch which elevates the rocks in the vicinity of Brownsville.

West of this Saltzburg and Brownsville axis is the deeper and much broader basin of the counties of Washington, Alle-

ghany and Greene, traversed only by a few low undulations not of length and force enough to divide the general one into subordinate troughs like those in the district east of the Monongahela River.

The Monongahela River Region.

"The Monongahela River, which rises in the northern central part of the West Virginia coal-region, flows north in Pennsylvania, and along the great basin, and keeps very nearly at the same geological level, so that its coal-outcrops line the river-banks at the same height for many miles. This river flows in the Barren Measures, or just at the base of the upper coal-measures, and thus gives access by innumerable gangways to the great Pittsburg-bed, and the three or four Greene County (Pennsylvania) beds above it," which have just been described.

"The Monongahela Valley has beautiful hill-slopes of soft shales or cliffs of limestone-rock backed by a great rounded, smoothed, and cultivated up-country of grain-farms and sheep-walks, formed of the soft shales and mud-rock formations which lie at the very top of the whole bituminous coal-system, far above the upper coal-measures, unbroken by ravines, and scarcely indented by valleys."—(*Lesley.*)

It is seldom that a seam of coal is so well defined and so easily followed as this Pittsburg seam. In travelling up the Monongahela River, as well as the Youghiogheny, a person can trace it from hill to hill, and can easily perceive, as he ascends the former river, that the coal-banks, as they are called, in this country, are becoming nearer the water's edge at every hill he passes, until at Greensboro, Pennsylvania, and Morgantown, in West Virginia, they are within a short distance of the water's edge. As you retire from the river and follow out the creeks, you find this stratum of coal on their shelving banks, and sometimes forming the beds of the runs. As you go westward toward the heads of the streams, it has sunk beneath the surface too far to be reached except by shafts. Thus, in Washington and Greene Counties, Pennsylvania, there is but little coal to be found in the face of the hills, the country being covered by the upper shales piled up high above the Pittsburg seam. Judging from the general structure of the coal-field, we may expect to

find a similar formation extending in a southwest direction along the east side of the Ohio River far into West Virginia, and covering a large part of the western side of that State.

"The Pittsburg seam may be observed at the following elevation above the Monongahela River in descending the stream at different places, viz., Morgantown, West Virginia, 180 feet; at Greensboro, 13 miles below, and two miles below the Pennsylvania line, 200 feet. Below Brownsville it dips nearly into the river, but rises again regularly as we go down the river, till at Williamsport it is 150 feet, at Elizabethtown 200 feet, and at Pittsburg 300 feet. Below Greensboro the elevations are approximate only, but above that place they are actual measurements. The seams of coal of the lower coal-measures have been reached in boring for salt-water at Pittsburg, Greensboro, on the Conemaugh, and at various other places. The depth to the first two seams at Pittsburg was 140 and 180 feet below the Ohio River."—(*Hildreth.*)

"The accompanying view of the great Pittsburg seam of coal, 10 feet thick, was taken by Sir Charles Lyell at Brownsville, in Fayette County, looking down the river. The coal is here near the water's edge, and the same seam is seen at a distance on the right bank at *a*, and may be followed the whole way to Pittsburg, 50 miles distant. As it rises slightly while the river descends, it crops out at a continually increasing but never at an inconvenient height above the Monongahela. In the sketch is also shown another layer of workable coal (at *d d*), being the Greensburg seam, which breaks out on the slope of the hills at a greater height. Here almost every proprietor can open a coal-pit on his own land, and, the stratification being very regular, he may calculate with precision the depth at which coal may be won. Horizontal galleries may be driven everywhere at very slight expense, and so worked as to drain themselves, while the cars, laden with coal and attached to each other, glide down on a railway so as to deliver their burden into barges moored to the river's bank."—(*Lyell's Elements*, page 392.)

The Monongahela River for about 95 miles, from the Virginia State line to Pittsburg, possesses every important advantage for the production of coal. It is, therefore, not surprising that the annual tonnage of this district is larger than

Fig. 35.

View of the great Coal [redacted] on the Monongahela at Brownsville, Pennsylvania.

a Ten-foot seam of coal.
b. Black bituminous or carbonaceous shale, 10 feet thick.
c Micaceous sandstone.
d d. Upper seam of coal, 6 feet thick.

that of any other bituminous coal-region in the United States. The coal is of an excellent quality for iron-making, for generating steam, for gas, and for domestic purposes. It is found in unlimited quantities in the hills on both sides of the river, at short distances only from the water, the coal being often run from the mouths of the mines, by slides or inclined planes, into the boats. The seam is of a good workable thickness—4½ feet and upward of pure coal—it lies altogether above the level of the river throughout that whole distance, with remarkable regularity in its size and position, the region being free from the undulations which are more common in the lower coal-measures farther north. The facilities for mining are excellent, and the transportation being by water is cheaper and for longer distances than that of any other coal-region in the United States. The Monongahela River is made navigable, at all seasons of the year, by dams, with locks large enough for steamboats, and the largest coal-boats, each carrying 800 tons, and barges carrying 440 tons. It may be called the perfection of a coal-region.

The city of Pittsburg being chiefly supplied with coal by railroad, a large portion of the Monongahela River coal is run down the Ohio and Mississippi to market, the distance from Pittsburg to New Orleans by river being 2,096 miles, through many States, with numerous populous cities and towns to be supplied with coal. There were 2,157,583 tons of coal shipped in the year 1873, by the Monongahela navigation alone.

The Pittsburg Coal-Trade.

"The period at which coal was first mined at Pittsburg is not on record; but in 1684, 20 years after Colonel John Campbell laid out its first plan of lots, privilege was granted by the Penns to mine coal from the hill opposite the city, the privilege being granted for £30 sterling per lot 'to dig coal as far in as the perpendicular line falling from the summit of the hill.' From that day to the present, Coal Hill, as it is familiarly called, has furnished large quantities of fuel to Pittsburg; but from a lot extending into the hill to where a line would fall perpendicular, from its summit, the privilege has spread 70 miles up the Monongahela River; as many up the Youghi

ogheny, and 20 or more outward along the tracks of the Pennsylvania Central & Alleghany Valley Railroads. Over and along all these districts Pittsburg coal companies reach out their hands and bring from the coal-seams millions of tons yearly to the city for home consumption and for export.

"The slackwater navigation of the Monongahela River has enabled the coal-veins of that stream to be the most extensively opened. Those veins range from 4½ feet in thickness at Pittsburg, to 7 and 8 feet at Brownsville and its neighborhood, where Lyell records he found them 10 feet. The slackwater of the Monongahela is divided into several pools, in five of which there are collieries.

"In the transportation of coal, there are used three classes of boats, known as barges, flats, and boats. Those known as boats are the old-fashioned "broad-horns," being large flat-bottomed boats of an oblong shape, from 125 to 150 feet long, about 16 feet wide and 8 feet deep, with flat sides, bows and sterns. They have a capacity to hold 20,000 bushels each, and, lashed in pairs, are floated by the current of the Ohio River to the lower markets of the Ohio and Mississippi Valleys. Barges are used in the towing of coal to the lower markets, and are built with modelled hulls. They contain, loaded, about 11,000 bushels. Flats are used for coal brought to the city for home consumption. They hold 2,000 bushels each." The amount of coal taken from the Monongahela collieries during the 25 years in which they have been opened, together with the amount consumed at Pittsburg, and that exported, is shown in the tables of statistics in the latter part of this volume. The progressive increase in the trade as well as its vicissitudes, caused by the war and by low water in the Ohio River, can be seen by the table of the annual production. The tables of monthly shipments show that the business is even larger in the winter than in the summer, the smallest tonnage being in July, August, and September.

"The collieries of the Pennsylvania Central Railroad form another important division of the coal-trade of Pittsburg. There are several collieries on this road which might be properly classed as belonging to that branch of Pittsburg industry, but part of their coal is taken East. There are, however, a number

of firms the product of whose mines is principally brought to Pittsburg for market.

"Another division of the coal-trade of Pittsburg may be classed as the city collieries, being those mining coal in the hills immediately adjoining the city. Some of these are the special collieries of rolling-mills whose works are contiguous, and the coal is run immediately into the yards of the mills from the mines."—(*Thurston.*)

As a peaceful, prosperous country, undisturbed by revolutions, war, and battles, affords but little material for the historian, so this great Pittsburg coal-region is so uniform in its strata, so simple in its structure, so free from synclinals and anticlinals, and yet its treasures of fuel are so well exposed by the valleys which cut down through it, and its channels to market provided by Nature are so obvious, that but little is required by way of description, and nothing is left for conjecture. Its prominent points are: its great regularity and uniformity over an extensive district, the excellent quality of its coal, its cheapness of production, and its unparalleled advantages for long transportation. The smoky, noisy, busy, iron-making city of Pittsburg owes its existence to this coal-seam, and is a characteristic example of what can be effected in a region favored by Nature with a great supply of a good quality of coal. But its influence is not confined to so limited a locality, as this is the great gas-coal of the country. Every dwelling in nearly every city or town of any size in the United States derives its light from Pittsburg coal, while those in the rural districts are indebted for their light to the oil-wells of the Alleghany River and its famous tributary, Oil Creek, so that the two great valleys of Western Pennsylvania furnish light to the United States.

The Lower Coal-Measures in the Monongahela Valley.

Although the large Pittsburg bed will supply all this section of country, and a vast region besides, for many centuries to come, yet we feel a curiosity to know something of the lower coal-measures which must underlie this southwestern part of the State. These can be examined, as they lean against the western slope of the Chestnut Ridge, at the base of which the

strata, next below the large coal-seam, have been swept away along a range of depressions, disuniting the outcrop of this main seam from the flank of the mountain. The lower coal-measures consist of sandstone, limestone, slates, and thin beds of coal. In this portion of the formation there are four beds of coal, and, in two or three localities, two other very thin ones which are not apparently persistent. Only two of the four beds are sufficiently thick to be wrought, the rest measuring from 6 to 20 inches, and sometimes two feet. The two available beds vary in thickness from 18 inches to 5 feet, the uppermost being commonly the thickest. They are situated low in the series, the inferior one holding a position from 20 to 70 feet above the great conglomerate, and the other large bed lying from 50 to 150 feet above the first. They are seen in the transverse ravines, which cut the flank and base of the Chestnut Ridge, and are associated with the first thick sandstones overlying the conglomerate. They are, also, brought above the surface west of the mountain in the anticlinal arches already described, where they are exposed in the little valleys that intersect these axes. They are thus seen on the Conemaugh, above Saltzburg, and on the Loyalhanna. On the Sewickly, likewise, both these beds are exposed, the uppermost being mined for fuel at the salt-works of that stream. These coal-beds are again intersected by the valleys of Jacob's Creek, of the Youghiogheny, and of the Redstone Creek in Fayette County.

It is worthy of notice that, all through Southern Pennsylvania, Maryland, and Northern Virginia, where the coal-seams of the upper coal-measures are well developed, those of the lower coal-measures are thin. Also, that, as the Pittsburg seam lessens in size in going farther south, the seams of the lower coal-measures become enlarged as in the Kanawha region, near Charleston, West Virginia. Both in the anthracite and bituminous regions a very large coal-bed appears to impoverish the others. The gradual and constant enlargement of some of the coal-seams, when traced in certain courses, is very observable, and indicates how uniform were the influences which operated over a very extensive region of country.

The Bituminous Coal-Field, as seen along the line of the Pennsylvania Railroad.

The great line of travel through the Pennsylvania bituminous coal-regions is by the railroad from Philadelphia to Pittsburg. The following is an account of what is seen on this route:

"One of the most interesting places along the route of the Pennsylvania Railroad is Johnstown, where are situated the great Cambria Iron Company's Works, which occupy the river-bottom, and are overhung by cliffs of the lower coal-measures, here lying nearly horizontal, and mined for coal, iron, and limestone, through to the ravines behind.

"In the country to the south of Johnstown lie the beautiful glades of Somerset. It is a wide and double coal-basin, bounded by the Alleghany Mountain on the east, and the Laurel Ridge on the west. Through this Laurel Ridge, as it is called, although it is 1,200 feet high, the Conemaugh breaks its way directly in front of Johnstown, cutting a gorge, the walls of which are coped with vertical cliffs of conglomerate, admitting the traveller into the similar but narrower Ligonier Valley. Through this coal-basin, river, canal, and railway hasten, until they enter a second gateway, cut through the Chestnut Ridge, a mountain parallel with Laurel Hill and quite as high, and their summits about ten miles apart. The beds of the lower coal-measures only fill these basins. The Pittsburg or Westmoreland coal-bed, and those above it, have been swept away from all this Cambria, Somerset, and Fayette country. Only one small patch of it is left on the top of a narrow, little hill south of Bolivar. The Chestnut Ridge, which bounds the second coal-basin on the west, is the last of the mountains. Beyond this lies the open country of Western Pennsylvania. The country along the Pennsylvania Railroad, west of Chestnut Ridge, is almost wholly covered with the Pittsburg coal-bed and the measures over it. The traveller will see about Latrobe large openings made in this wonderful deposit, and it is laid open for rods at a time in the cuts west of Greensburg. Descending Turtle Creek, turnouts, coal-bins, coal-trains, and open gangways connected with mining, multiply. At Irwin Station we are in the centre of the most important gas-coal mining-region in

[illegible]. The bed [illegible] above water-level [illegible] and in some places [illegible] and beyond the [illegible]. [illegible] through the entire Westmoreland County, rising and falling now above and now below the water-level of the streams, now [illegible], then [illegible] and [illegible], and finally [illegible] and [illegible] feet thick when it reaches Connellsville. Westward it slowly sinks beneath the Greene and Washington County, Pennsylvania [illegible] to reappear in the Ohio River and its branches in Southern Ohio. This amazing layer of [illegible] [illegible] so immense that the whole present [illegible] [illegible] would be supplied from it alone, and in Southwestern Pennsylvania alone for more than a thousand years. Through this wide treasury of wealth and power the Pennsylvania Railway passes all the way from where it leaves the Conemaugh [illegible] miles from Blairsville until it enters Pittsburg.

"At Pittsburg the upper coal-beds, or Pittsburg seam, are in the hills [illegible] feet and more above the water-level. Numerous inclined planes connect the mines above with the railroad and steamboat landings below. The great field of the coal stretches south of the Ohio River, through Washington and Greene Counties, and through the Virginia Panhandle. Some few of the highest hill-tops north of the river catch the big bed and offer facilities for local small coal-works.

"From the great bed down to water-level at Pittsburg, the hillsides are formed of the Barren Measures, with a few thin worthless seams of coal, and a great thickness of red shales which show all the roads and fields and railroad cuttings back of Grant's Hill. Under water-level at Pittsburg the rocks are barren of coal for a depth of about 300 feet. At 3[illegible] or 300 feet, shafts sunk in the river bottoms begin to strike the top beds of the lower coal-system, which rise in going up the Allegheny River until they get above water-level at Freeport. Still lower beds come out at Kittanning, and finally the bottom rocks of the coal-measures reach the surface at Brady's Bend."—From the *United States Railroad and Mining Register*, Philadelphia.)

As a general review of the most important regions of Pennsylvania, in an economical aspect, or those producing the largest quantities of coal, the following division may be made of the whole field, producing in all 24,000,000 tons.

1. The anthracite region, which produced, in 1871, 15,000,-000 tons.

2. The semi-bituminous regions of Blossburg, Barclay, McIntyre, Snowshoe, Phillipsburg, Johnstown, and Broad Top, which in 1871 produced about 3,000,000 tons.

3. The bituminous region on the line of the Philadelphia & Erie Railroad, or West Branch, producing 100,000 tons.

4. The block-coal region of Mercer County and vicinity, about 500,000 tons.

5. The Alleghany Valley region, about 400,000 tons.

6. The Westmoreland gas-coal region on the Pennsylvania Railroad, including only the coal carried eastward, 1,000,000 tons.

7. The Pittsburg coal-trade, including that consumed at Pittsburg, the whole being about 4,000,000 tons, derived from: (1) the Monongahela Navigation; (2) the Connellsville coal and coke region; (3) from the river below Pittsburg; (4) the Pittsburg, Cincinnati & St. Louis, or Panhandle Railroad; (5) the Pennsylvania, and other railroads; (6) the Little Saw-mill Railroad; and (7) the collieries above Pittsburg, used without passing over any of the great lines of transportation.

The full statistics of each region will be given in the Appendix, and a law of Pennsylvania dated May 9, 1871, now provides for the publication by the State, annually, of a full account of the mineral statistics of Pennsylvania, especially those of coal.

CONCLUSION.

It would be tedious and unprofitable to the general reader to give a multitude of further details, which might be collected, as what have been given have been, from the ponderous volumes of Rogers's final report, as well as from his six annual reports, and from other sources of a later date, of the vast body of coal which fills this western part of Pennsylvania. Whole counties are covered with coal-seams of greater or less thickness, in quantities to which the hackneyed phrase of inexhaustible might be applied without exaggeration. But as it is not here proposed to collect for the use of future generations minute particulars of our mineral resources, but rather to give a picture of the living present, it will be sufficient, after giving these general features of the whole region, to refer to the statistics of

those particular districts from which the coal we are now using is derived, as given in the latter part of this volume, and to the special accounts already given of those localities which a large production seems to have entitled to a more detailed notice, the object throughout being to treat the subject with more reference to business than to science.

An examination of the situation on the map of the avenues to market, and of the situation of the several productive regions, will show the reader at a glance what very large coal-regions of the State are as yet entirely undeveloped, except for the very small quantities required for domestic use throughout a thinly-populated country. The official statistics show how really small is the coal-trade, and how much it is over-estimated in the statements often published, which are generally the result of mere surmise.

In examining the reports of geologists, and other descriptions of many of the districts as they existed but a few years ago, and comparing them with the present developments, we cannot but notice that new seams of coal, or those of larger size and better quality, or adapted to special uses, are rapidly being discovered; leading to the fair inference that in many of these secluded valleys, or buried in profound stillness in the mountain-basins of our roadless, wilderness country, there may be now reposing other unsuspected mineral treasures, even as valuable as that wonder of the age, petroleum, which may at some distant day give rise to other Scrantons and Pittsburgs, or perhaps Titusvilles and Corrys. Proper examinations with a view to their discovery must be made on an extended scale, and these the greatest of the mineral-producing States (Pennsylvania) supinely refuses to undertake.

One of the most fortunate circumstances for the resources of this western portion of our State is noticed by Prof. Rogers, arising out of its peculiar geological structure, and to be found in the universal rolling outline of its surface, which is everywhere trenched by ravines and by more or less deep valleys, the result of an extensive denudation by water. This feature gives us ready access to the strata and all their contents which lie above the lowest level of the country. This peculiar geological and topographical structure of our coal-fields, affording a

ready access to the coal, is of great importance for the purposes of its development.

Americans are sometimes chargeable with drawing exaggerated pictures of their great resources. But, in all soberness, the coal-fields of Pennsylvania may with propriety be called magnificent. They are situated within a reasonable distance of the seaboard, near the largest population and the largest cities, and where the cheapest transportation by land and water can be obtained. There is no coal farther east or farther north; "the geological revolutions which have robbed other States of mineral fuel have left her in possession of some of the largest and richest coal-fields of which any country can boast." Observe their immense extent, the wide range and great thickness of many of the coal-seams, the great variety in the character of the mineral itself, showing every known gradation from the hardest to the softest anthracite, several varieties of semi-bituminous and every possible valuable variety of bituminous coal, shading off from the semi-bituminous to the moderately and up to the highly bituminous or most gaseous, the cannel-coals, and finally, on our northwestern borders, that nothing may be wanting, we have the hard splint or block iron-smelting and steam coal of the Mercer district. The excellent qualities of all these coals is a point which we cannot realize, until we see and use the coals of the Western States so heavily impregnated with sulphur and water. The dryness and purity of our Pennsylvania coals are invaluable qualities.

But it must not be forgotten that all of these mineral riches would be nothing in themselves, for Spain is said to possess one of the best coal-fields in Europe. Fortunately, the Pennsylvania coal-region, that vast storehouse of latent power, is found in a country with a good government, where the laws protecting men in their rights and property are well and faithfully executed, inhabited by a Christian, educated, and energetic people, with a climate the best calculated for the development of the mental faculties and physical powers of man, where the predominant religious belief instils the best moral principles, where labor of all kinds is honorable, and where, in the levying of import duties, that proper degree of protection is afforded which is due to her industrious and enterprising citizens.

THE GEOLOGICAL SURVEY OF PENNSYLVANIA.

The only geological survey of this State was commenced early in the year 1836, under the sole direction of Henry Darwin Rogers, and was prosecuted for six years. The work was then suspended, now 30 years ago, but Prof. Rogers continued the explorations, and the preparation of his final report, for three years longer. His report was ready for publication early in the year 1847, but was not then published. In 1851 he was authorized to resurvey portions of the State, which was done during that year; and, in fact, he continued at work at intervals until the spring of 1855, when an arrangement was made with him by which he was to publish his final report at his own expense, for which an appropriation was made to him by the State. The report was duly published, in two large quarto volumes bound in three, with a large geological map of the State, and a separate map of the anthracite coal-regions, in the spring of 1858, or 22 years after the general survey was begun, and 16 years after it had been first discontinued. Six annual reports of progress had been printed in pamphlets for the years 1837 to 1842 inclusive, containing in all 693 pages, 8vo, which have been consulted in the preparation of this work; but these soon went out of print or were lost, so that the only permanent result, in a literary way, is contained in the three large volumes and the maps mentioned. Even these were, for a long time, not kept anywhere on sale; but since the death of Prof. Rogers they have been for sale by D. Van Nostrand & Co., booksellers in New York, at $30 per copy. The books are well printed and beautifully illustrated, the work being done at Edinburgh, in Scotland, where Prof. Rogers spent the last years of his life as Professor of Geology in the university. It is a noble work, worthy of the men of genius who produced it, and of the great State whose geology it describes, and is much finer, as a mere book, than any of the other State reports thus far published. Time proves its great accuracy and value. It forms the basis of this account of the Pennsylvania coal-regions, the principal facts on coal being here condensed. In regard to this geological report, it is unfortunate that it is written in a dead language, Prof. Rogers having adopted a new nomenclature for the geological formations, of his own invention, which

no other geologist has ever adopted, but those who are obliged to use his report. Those who have studied the systems of geology in common use must provide themselves with a key by which to translate the Pennsylvania survey, such as that given on page 115. If we ever have another, it is hoped the geological terms and phrases of the day will be used. The following list includes the names of all the assistants of Prof. H. D. Rogers, viz.: John F. Frazer, James C. Booth, Samuel S. Haldeman, Alexander McKinley, C. B. Trego, James D. Whelpley, Alfred F. Darby, H. B. Holl, James T. Hodge, R. M. Jackson, W. H. Henderson, P. W. Sheafer, Townsend Ward, W. H. Boyd, J. P. Lesley, John C. McKinney, E. Desor, Robert E. Rogers, W. B. Rogers, A. A. Dalsen, Leo Lesquereux, H. W. Poole, Edward Haldeman, Horace Moser, and Martin H. Boyé. Among these, several names will be recognized of those who have become eminent in the scientific world.

The following sketch of the part performed by some of the principal assistants in this State Geological Survey is by one of their own number:

"This immense work of nearly 2,000 pages, magnificently illustrated with maps, sections, and pictures of all kinds, to the number of nearly 1,000, is the result of the toil of many men, for many years. . . . Whelpley unfolded the mysterious structure of the anthracite regions, before unknown; Henderson and McKinley traced out all the beautiful intricacies of the Upper Silurian and Devonian country of Middle Pennsylvania; Hodge gave us the first grand *coup d'œil* of the bituminous coal-basins for 200 miles; Sheafer worked out the details of the regions which Whelpley was the first to comprehend; Jackson constructed the scheme of the Upper coal-measures of the West, and studied the Silurian and Devonian belts of Centre, Huntingdon, Blair, and Bedford; McKinney, Boyé and Holl taught us what we know of the lower coal-measures of the Alleghany and Ohio River regions, all working with self-taught, unassisted skill, with a zeal which inspired their science, and a genius which overcame all the obstacles to knowledge at that early day. The brilliant overture to the survey was by Booth and Frazer, the noble second act by Desor and Lesquereux, and the fine completion of it in true

artistic style by Dalsen. The writer's (J. P. Lesley) name has been erased from the map of Pennsylvania which he alone constructed and compiled, from the thirteen great sections across the State, the very style of which he was obliged to invent, from all the vertical sections of the coal-measures which he was the first to propose and alone executed, from the hundreds of illustrations of the geology of the State which he re-drew, some from his own original notes, many from the fine diagrams of Whelpley (diagrams unique at that day), and many more from the less perfect pen-and-pencil sketches of other members of the survey, and . . . . his name is attached once, and only once, and that in common with two other names, to the map of the anthracite region, with which he had nothing whatever to do, never having seen it until it was published."—(Preface to the *Iron Manufacturer's Guide.*)

All the appropriations made by the State for the survey, from 1836 to 1855, appear by the statute laws to have amounted to $111,570, of which $34,750 was for the publication of the report, leaving only $76,820 spent in making the survey itself. Unfortunate as was the delay attending its publication, and the loss from the failure of the first contractors for printing the final report, yet the State has never before or since derived so much benefit from the expenditure of the same sum of money. No State now so much needs another geological survey as Pennsylvania. The four great States west of her, Ohio, Indiana, Illinois, and Iowa, have added wonderfully to their knowledge of their mineral wealth by recent geological surveys, all now nearly completed. It is confidently hoped that a similar work will again be undertaken at an early day by this the greatest of the coal-producing States. The information contained in this volume should create a desire for more.

NOTE.—By an act of the Legislature, approved May 14, 1874, a second geological survey of Pennsylvania has been authorized under the direction of a board of ten commissioners, with the Governor as chairman. Prof. J. P. Lesley, of the University of Pennsylvania, has been appointed the State geologist.

XI.

MARYLAND.

The Cumberland (Maryland) coal-region is one of the most important of the bituminous coal-regions in America, on account of the good quality of its coal, the unusual size ot the bed, and the large amount of its production. The aggregate tonnage of this district since the beginning of its coal-trade is 21,253,685 tons, and that of the year 1872 was 2,355,471 tons. The coal has a world-wide fame as an iron-making and steam coal. Every ocean-steamer uses it, except only those of the United States Navy, which all burn anthracite, on account of the absence of smoke, which would betray the vicinity of the vessels. Every railroad company south of Pennsylvania and east of Albany, New York, uses this coal in locomotives. It is the only blacksmith-coal on the seaboard, and it is quite extensively used for steam-purposes generally.

This chapter might with propriety have been placed next in order after that on the semi-bituminous districts of Pennsylvania. As before explained, the Blossburg, Ralston, and Towanda district, in Northern Pennsylvania, the Snowshoe and Phillipsburg, in the central part of that State, and the Broad Top, together with this Cumberland basin, are the most eastern and apparently outlying detached fields of the great Alleghany bituminous coal-formation of the United States. They occupy the intermediate zone between the anthracite and true bituminous coal, running in a northeast and southwest direction. (*See* miniature map on page 185.) They all produce coal of the same general character, with nearly the same analysis, being the close-burning species, or the kind which cakes or melts in burning to a greater or less degree, forming a crust, or what

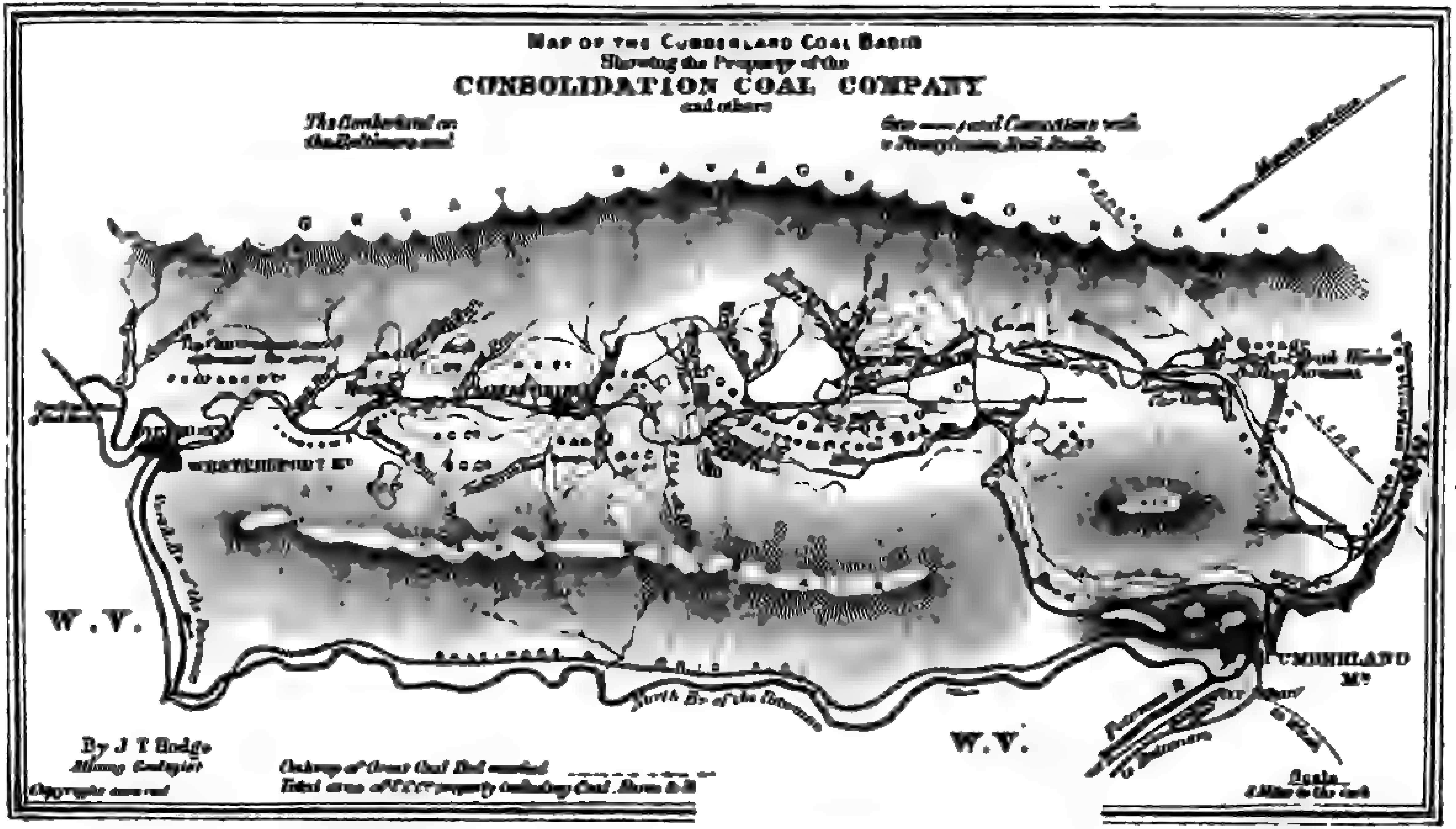
smiths call a hollow fire, and in America it is called semi-bituminous coal. It has never been found in any other locality in the United States except in this range. The open-burning kinds of bituminous coal, which are produced farther northwest than these regions, burn with a more extensive flame, which passes freely through the coals. This species of coal is specially adapted for manufacturing purposes and for generating steam, and the quantity consumed in any locality where it is accessible forms a very fair measure of the industrial and productive greatness of a country.

The Cumberland, or, as it is sometimes called, the Frostburg, or George's Creek coal-field, is situated in Alleghany County, Maryland, and occupies the eastern part of the small triangular territory which forms the western extremity of that State. While the Baltimore & Ohio Railroad follows the Potomac River from Cumberland westward, the Cumberland & Pennsylvania Railroad, as it is called, which passes through the coal-region, runs from Cumberland northward, and then southwestward, after passing through a remarkable gap of Wills' Mountain, a locality which is as interesting to the geologist as it is imposing to the traveller.[1] The width of this gap is estimated at about 500 feet to the base of the mountains, the distance through the mountain being more than a mile, and it forms an excavation of upward of 850 feet in depth. It is the natural outlet for the united waters of Wills' Creek, and Jennings's and Braddock's Runs, that empty into the Potomac at Cumberland. The rocky strata that present themselves in this gap are very interesting. On the southeast side of the mountain the summit is reached by a gradual ascent over a coarse, grayish sandstone, superimposed upon a red sandstone, the grade of the ascent indicating the inclination of the strata at an angle of about 30°. At the summit the strata are horizontal, or nearly so, overlying a precipice of about 300 feet, at the bottom of which is an extensive talus of fallen pieces, reaching to the bottom of the gap. On the northwest side the strata of grayish sandstone are nearly vertical, as if they had been forcibly compressed against the flank of the mountain.

[1] The data for a portion of the topography and geology of this chapter are derived from the report of Prof. Ducatel, the State Geologist of Maryland.

The Frostburg or Cumberland coal-basin, the most interesting and important feature in the geology and physical geography of this country, is reached through this gap of Wills' Mountain, first by the valley of Braddock's Run, by the railroad of the Cumberland Coal & Iron Company, 16 miles in length, to their mines on Dan's Mountain, in the northeast part of the coal-field, east of Frostburg, pursuing, for a part of the distance, the route of the old National Road or Turnpike; or, secondly, by ascending Wills' Creek to where it receives Jennings's Run, where the Cumberland & Pennsylvania Railroad follows its ravine by switch-backs and heavy grades to a summit at Frostburg; and then, after passing a tunnel through a ridge in that village which connects Dan's Mountain and the Great Savage Mountain, it descends through the valley of George's Creek to the Baltimore & Ohio Railroad at Piedmont, on the Potomac River. The length of this railroad is 34 miles. By both of these routes, on Braddock's Run and Jennings's Run, the predominant rocks observed are encrinital limestones and red sandstones. The coal-region can also be reached by the Baltimore & Ohio Railroad route from Cumberland along the Potomac to Piedmont, 28 miles, and thence returning by ascending George's Creek.

The situation of the Cumberland coal-basin is between Dan's Mountain to the east or southeast, and Savage Mountain to the west or northwest, and the limits of the Big Seam extend within the State of Maryland in a southwest direction 20 miles in length with an average breadth of 4½ miles, but without covering the whole of this area. There is a transverse ridge, as before stated, nearly as high as the principal mountains mentioned, upon which Frostburg stands, connecting the two mountains just named, and on which the old National Road was built. This divides the basin into two unequal parts, and determines two distinct and opposite directions of drainage, and two different routes to market for the coal produced in these different parts. The northern or eastern portion, which is much the smaller, occupying about one-fourth of the whole basin in Maryland, is principally drained by Jennings's Run, which takes its rise at Frostburg, and receives as tributaries on the north side, from the Savage Mountain, Cranberry



MAP OF THE CUMBERLAND COAL BASIN
Showing the Property of the
CONSOLIDATION COAL COMPANY
and others
W. V.
W. V.
CUMBERLAND
By J T Hodge

Run, Workman's and Mattingly Runs and Weller's Branch, and from the Dan Mountain, on the south side, Trotter's Run. These all unite within the basin, and, flowing through a gap between Dan and Piney Mountains, finally empty into Wills' creek three miles north of Cumberland. The coal mined east of the Frostburg summit descends the railroad to Cumberland.

Braddock's Run also takes its rise near Frostburg, and in the northern portion of the coal-basin, and, receiving Preston's Run, flows easterly through a gap in Dan's Mountain, and empties likewise into Wills' Creek two miles north of Cumberland. The coal of the Cumberland Coal & Iron Company descends their railroad, before described, by this route to Cumberland.

The southern portion of the basin, forming three-fourths of the whole, is drained by George's Creek, with its numerous tributaries both from the Dan and Savage Mountains, the principal of which lateral streams going westward are Neff's, Elk-Lick, Hill's, Jackson's and Moore's Runs, that rise in Dan, and Winebrenner's, Wright's, Squirrel Neck, Koontz, Laurel, Bartlett, and Mill Runs, that come from Savage. The whole length of George's Creek is 22 miles, and it empties into the Potomac at Piedmont, 28 miles above Cumberland, or 206 miles by the Baltimore & Ohio Railroad west of Baltimore. The coal mined on George's Creek descends the Cumberland & Pennsylvania Railroad to Piedmont, and passes thence by the Baltimore & Ohio Railroad to Baltimore. The great importance of this coal-region is a sufficient justification for these details of its various localities. In the coal world, these creeks and runs have the same importance as the famous streets of our large cities have in the commercial world.

The structure of this coal-basin is simple, but very interesting as a geological study. It reminds us of the anthracite basins in its bounding ridges of steeply-inclined strata, but there the resemblance ceases. For, whereas the anthracite basins are canoe-shaped, narrowing and rising at the ends where the mountains are closed up together, squeezing the coal up to a point; on the contrary, at Cumberland, the two mountains are parallel throughout.[1] The trough being thus left open at the ends, therefore, when the work of denudation began, the waters divided at the Frostburg summit as the continent was elevated,

[1] The points of this basin are in Pennsylvania and Virginia.

and the great coal-seam was wasted away in both directions. The connecting ridge, extending from Dan to Savage Mountains, retains a full section of the great coal-bed, extending from mountain to mountain. This body of coal is about four miles in width, or in a northeast and southwest direction, and, as the coal here must be mined by shafts requiring hoisting and pumping, comparatively little mining has as yet been done in this portion of the field. An examination of the accompanying map will show how the valley of George's Creek is cut down through the large coal-bed, leaving first two narrow fields, one on each side of the valley, in which the outcrops of the coal-bed become higher and higher on the hill-sides as you proceed from Frostburg to Piedmont, lateral streams finally even separating these into smaller detached coal-fields.

As to the internal structure of this basin, if we suppose a transverse section of it to be made, it would be found to exhibit a succession of alternating strata, of various thickness, of sandstones, slates, coal, iron-ore, fire-clay, and limestone, disposed in a moderate curve, and filling up the valley between the two prominent ridges designated as Savage and Dan's Mountains. The Frostburg summit is 1,300 feet above Cumberland, and, for some distance on the southwest side, the coal-strata, not having been interfered with by denudation, extend in a trough-like form far underground across the valley from mountain to mountain, but at the extremities of the basin, as before remarked, where the valley is cut down to a great depth, the main seam crops out at some elevation on the sides of the valleys. The surface of the basin, of course, is irregular, being intersected by deep ravines formed by the streams and runs that traverse it. George's Creek, in a distance of 17 miles and in a longitudinal direction, has scooped out its bed, or rather some more general and powerful excavating cause has cut down through a mass of rocks 1,250 feet deep, carrying away an immense amount of the coal-field. The same is the case at the Jennings's-Run end of the field, while at Braddock's Run a small portion only has been removed; because, flo terally, it soon leaves the coal-basin. Other lacerations of the coal-basin have been produced by the lateral streams.

The Potomac River, too, enters the basin at its southwest

extremity, cutting through it diagonally, and carrying off parts of the principal upper beds of coal, but not affecting the dip or inclinations of those that remain, as the same fine 14-feet seam of coal seen on George's Creek is found on the West Virginia side, high up on the mountain at the Hampshire & Baltimore Company's mines above Piedmont, 1,000 feet above the Baltimore & Ohio Railroad, showing that the seam was once continuous. The only consolation for these great losses of parts of the coal-field is found in the facilities furnished for exploring and mining operations.

There is a very great regularity in this coal-basin, as faults or serious dislocations do not occur. The soil is excellent, yielding good crops, and the country is well timbered with oak, pine, locust, and other timber, which are valuable for mining purposes. The appearance of the country is very good, and there is no coal-region more inviting to the tourist.

The Coal-bed.—The seams of this species of coal are always thinner than the anthracite. They are generally found in positions more nearly horizontal and in parallel strata. But the great bed in which the mining is done in the Cumberland coal-region is of the extraordinary thickness of 14 feet. Scarcely anywhere in America is there a seam of bituminous coal of this size, extending, as this does, throughout the region, and maintaining its size wherever it occurs. This Big Seam, as it is called, is not only very uniform as to its thickness, but very regular in its form, without faults or breaks, and, like the upper seams in other regions, less disturbed and more easily traced than lower seams usually are. At the mines of the Hampshire & Baltimore Company (No. 25 on the map) may be seen this splendid bed of beautiful and pure coal mined out to nearly its full thickness of 14 feet, and, in some places in those mines, even 15 and 16 feet thick, with but one small layer of not exceeding an inch or two of slate within two feet of the bottom. A little of the coal is left in overhead as a roof in an arching form, and such is the height that the drivers ride into the mines on horseback, forming a strong contrast to the low and contracted roads in mines in the small seams of bituminous coal. These mines, however, are exceptional in this respect, this being an outlying detached coal-field west of

the George's Creek or Frostburg basin, and across and west of the Potomac River. Generally throughout the region from seven to nine feet of the coal only is worked, the top and bottom parts being left in on account of the slates and the supposed impurities they contain. Even these are a good thickness of coal, and make a mine very convenient in its working. At the old Cumberland Coal and Iron Company's mines they mine out nine feet of coal with two small seams of slate, together about two and a half inches in thickness. The bottom layer of coal is here taken out and the top one left in to strengthen the roof. At the Borden mines, near Frostburg, they also mine nine feet of coal, with two small seams of slate of one and a half inch, each about the middle, and about six inches apart. Here the bottom coal is also mined. At the Central mines, the American Company's, and others, down George's Creek, the upper small seam of slate disappears, and they mine about seven feet of pure coal. The above are given to show the great uniformity in the seam throughout the region, and that no locality has any special advantage. The bed of coal is certainly a very fine one, remarkably free from impurities, and everywhere affording a coal of admirable quality, as free from sulphur as any coal in this or any other country, without bony or incombustible matter, and with no slate that is troublesome or expensive to clean. No slate-pickers are anywhere employed in the region, as none of it need get into the coal, except through gross carelessness on the part of the miner, an offence for which, if committed, he is heavily fined.

The greatest disadvantage in this region is the want of a strong, self-sustaining roof over the coal, which, taken in connection with the great thickness of the seam, and the crumbling, soft character of the coal, causes a great loss of coal, which, by the present method of mining, is not taken from the mines. One who did not know of these circumstances would be surprised at the plan of the mines. The headings, or gangways, and air-ways, are nine feet wide, and the rooms, or breasts, only from 13 to 16 feet, the widest in the region being 18 feet. This is owing to the cover of soft slate making it necessary that three feet of the coal be left overhead, cut in an arching form by way of roof. The pillars of coal not mined, left between

the rooms, are 40 to 50 feet wide. Some of the companies venture to make cross-cuts 10 feet wide in the pillars, 50 feet apart, so as to get more coal, but others think it is not safe to do so. It will be seen, from the smallness of the rooms and the great size of the pillars, that but a small proportion of the coal is taken out, and it is said that no pillars have been successfully removed in the region without bringing on "a thrust," or fall of the roof. It is thought that no land in the region produces more than 5,000 to 6,000 tons of coal to the acre, so that this very large seam of coal is no great advantage unless some method of getting out more of the coal can be contrived. A much thinner seam, with a strong, sound roof, would produce more coal to the acre. This great waste in mining is not a pleasant spectacle, and the region is greatly in want of some first-rate mining engineers, and a much improved system of mining. The present plan is shockingly wasteful.

The following is a portion of Prof. Hodge's report in regard to the thickness of coal mined in this region, the system of mining, and the product of coal per acre:

"It is common to call this the 'Fourteen-foot Bed,' and in the lower end of the basin it has been found of this thickness, and to some extent has been so worked. But this name gives a very incorrect impression as to the amount of coal actually obtained from any of the mines. At those now worked in the northern end of the basin the real thickness of the bed is about eight and a half feet, and still farther to the northeast the bed becomes thinner and poorer by increased intermixture of seams of slate. In the central portion of the basin, although its thickness may reach 12 feet, there is hardly a mine in which it can be said that more than 10 feet of coal is worked to any extent, while the most of them save only about seven feet. Various reasons are given in explanation of this. In some mines the slate roof over the coal-bed, when undermined, is apt to fall in blocks, or 'slips,' and endanger the lives of the miners. In these mines it is almost a necessity to leave the upper two or three feet of the coal-bed for a safe roof, and remove only the middle and lower portions. The roof-coal, as it is called, is often more or less streaked with layers of what is known as 'bony coal,' a variety of coal duller and more compact than the

rest, but otherwise entirely unobjectionable. Merely on account of this appearance, this portion of the bed is entirely lost, even when the overlying slates would make as safe a roof as the coal itself. In some mines, as at the Borden Shaft on George's Creek, where the roof-coal is left to the thickness of about two feet, and from nine to nine and a half feet taken out below it, a portion of the upper coal is expected to be saved, when the pillars are finally removed, and the whole roof is allowed to come down. This, however, is a very uncertain dependence.

"But the roof-coal is not the only part left unworked at many of the mines. Throughout the whole coal-field the lowest two or three feet of the bed contain one or two seams of slate, commonly two, each half an inch or so thick, and about a foot apart. They run with remarkable uniformity in parallel sheets through the coal of nearly all the mines, and, unless the fragments are carefully sorted out, they damage seriously the character and reputation of the coal in the market. In the destructive rivalry that has existed in the different companies, many have allowed this 'bench-coal' to remain unworked, and have been willing to pick out the choicest middle part only, and sacrifice all the rest.

"Thus it is that, in some of the mines, the bed is worked to its full thickness either throughout or partially; in some the roof-coal only is left, and then it may be with the expectation of recovering it in part; and, in some, both roof-coal and bench-coal are sacrificed to the extent of full five-twelfths of the whole bed. The workings of different mines thus varying, and of the same mine in different parts, it is impossible to determine correctly what average thickness is worked by any company. The length of the props they contract for and use is the best guide for estimating this.

"Besides the two little seams of slate in the bench-coal, the lower mines on Jennings's Run have another seam in the breast, or upper coal, which, as it was found in the Alleghany mine, runs from two inches to a foot in thickness. Its effects are so serious that the mines of this part of the basin are not now worked at all; though, being the nearest to Cumberland, they would have the least to pay for transportation.

"*System of Mining.*—The older mines of this region were

worked to a great extent in a reckless manner, without a proper plan for the final extraction of all the coal. That which was nearest at hand was taken out, and large areas were run through and then left in such condition that not only the coal in these could not be safely or economically removed, but the only available access to bodies of coal not reached was sometimes quite cut off. This was particularly the case in the workings under the town of Frostburg, where it is impossible to get any accurate knowledge of the value of what is left. But portions of other mines also are not much better off, and are altogether inaccessible, either by the falling in of the roof over the abandoned areas, or by the workings having filled with water. A better system of mining has been pretty generally in practice of late years; but the details differ so much in different mines, and indeed in different parts of the same mine, that the most experienced managers would disagree as to the number of acres fairly exhausted or rendered unavailable in any extensive mine. The general plan is to drive two parallel headings, 9 or 10 feet wide, and from 30 to 100 feet apart, having a block of coal between them as a pillar. The headings may reach any distance up to a mile or more, according to the extent of the property on the line they are directed. The object of driving two together is that, by means of occasional cross-headings connecting them, a system of ventilation is obtained. This is often perfected by connecting one of the headings with an air-shaft, at the bottom of which a fire may be kept up to increase the upward current of air which is supplied from the heading, and its course regulated by tight partitions with doors when needed. The double headings also serve another useful purpose, as separate roadways for the cars going in and out. At proper distances along the headings, openings branch off at an obtuse angle into the solid wall at the side, and having passed far enough for another pillar of proper width, the system of side rooms or chambers is commenced, parallel to each other and 12 to 18 feet wide; a greater width being admitted as the roof is sounder. The object of branching off at an obtuse angle from the main heading is, that the cars may be more easily run in and out from the main track. Pillars of coal are left between the rooms, varying in width in different mines, accord-

ing to the judgment of the mining captain. It is from these rooms that the chief supply of coal is obtained. The true system of working is to extend the headings and the rooms connected with them as near as possible to the extreme boundary of the property, and then, the rooms being exhausted, to proceed to take out as much as may be practicable of the blocks of coal or pillars left between them, beginning along the boundary and working back. The roof and the surface above are thus allowed to settle down. The main headings remain to the last, so far as they are needed as avenues, when the wide blocks on each side of them are finally removed. Instead of working out the extreme portions first, rooms are often worked near the entrance, as large supplies of coal can thus be more readily obtained; but in this case care is taken in well-conducted mines that the main headings are not disturbed, and that the exhaustion and destruction of the rooms, by removing the pillars and allowing the roof to fall in, shall not occasion obstruction to reaching portions of the coal-bed beyond. But, while this is now the general system upon which the mines are worked, there are no doubt differences in the care and skill exercised in keeping all parts of the mine available; and more or less coal is lost by miscalculations and accidents, by the roof coming down in places where not intended to settle, by pillars being crushed and buried, and areas only partially worked being blocked up, of which no account is made or ever can be. Then, as before remarked, it is still not uncommon, in the desire to get out the best coal as rapidly as possible, to leave the roof-coal and the bench-coal with its two little slates, and large bodies of pillars too, with the intention of taking them all up at some future time; but, as long as there is other property to work, the same reason, or rather a stronger one, exists for neglecting what was left behind, and the result is, this time never comes. Such being the condition of the mines, it is a hopeless undertaking to attempt to estimate, with any near approach to accuracy, the number of acres exhausted in mines that have been worked for the last fifteen or twenty years or more.

"This statement of the method of working and the condition of the mines cannot fail to suggest the great advantages that would be derived by bringing contiguous properties covering

large areas into one comprehensive system of working; and, further, the great saving that would be derived from breaking up the present competition between different mines by rendering it practicable to save the whole of the coal, instead of removing only 7 or 8 feet, when 10 or 12 might be mined.

"*Product to the Acre.*—Allowing 27 cubic feet to the ton, there should be for every foot thickness 1,613 tons to the acre, which would give, for 8¼ feet thickness, 13,310 tons, and for 10 feet, 16,130 tons. From the older workings no one supposes half this amount was actually obtained, and it would be a larger estimate than some would admit to put the probable yield of the best-conducted mines at the present time at 1,000 tons to the foot thickness. In case the pillars are all finally removed, however, it is not easy to explain what becomes of the coal, if the product does not considerably exceed this amount, for the fine coal all goes to market, and the loss by waste must be very small besides the 2½ per cent. or thereabouts reckoned as loss in transportation. In assuming some basis for calculation, it may therefore not be far out of the way to call the average product of the mines as they are now worked 1,000 tons to the foot thickness."

Extent of the Field.—The Cumberland coal-basin has been generally described as 30 miles long, extending from some distance beyond the Pennsylvania line across Alleghany County, Maryland, into West Virginia. The two rims of the basin, consisting of the Dan and Savage Mountains, are about four or five miles apart. But these dimensions would give a very exaggerated size to this coal-field, as the actual extent of the big bed, the only one that is worked, is very much less. Some of the estimates formerly gave but 9,000 acres of the Big Seam, while others placed it as high as 20,000 acres. In the summer of 1869 this question was set at rest by an elaborate and careful survey made by Prof. James T. Hodge, of Plymouth, Massachusetts, one of our best mining geologists. His report was published by the Consolidated Coal Company, and the results arrived at, as to the extent of the great bed, are contained in the following tabular statement:

TABLE OF PROPERTIES CONTAINING THE GREAT COAL-BED OF THE CUMBERLAND BASIN.

As reported by James T. Hodge, Mining Geologist, 1869.

NAME.	Acres of Coal.	Estimated number worked out.	Acres of Coal remaining.	Tons of Coal shipped up to September 30, 1869.	Distances from Cumberland and Piedmont.		
					Miles to Cumberland.	Miles to Piedmont.	Port where Coal is usually delivered.
Withers Mining Co.........	.....	....	....	27,792	....	......	......
New York Mining Co......	650?	....	650?	4,100	....	......	......
Alleghany Mining Co.......	391	100	291	614,843	14	20	Cumb.
Borden Mining Co.........	377	177	200	1,007,590	15	19	"
" " "	335	50	335	331,463	20	14	"
Cumberland Coal & Iron Co.	4,900	600	4,300	3,130,232	11 to 14	......	"
Consolidation Coal Co......	1,900	218	881	846,459	15	19	Cumb.
" " "				245,029	19¼	14¼	"
" " "	2,224	57	2,167	398,123	22¼	11¼	"
Wright Farm..............	484	....	484	....	....	......	.....
Blaen Avon Coal Co........	57	....	57	....	....	......	.....
Johnson (now Shaw).......	72	....	72	....	....	......	......
Midlothian Coal and Iron Co.	60	13	47	80,663	20	14	......
Koontz....................	500?	.....	500?	....	....	......	......
Hampshire & Balt. Coal Co.	86	43	43	805,928	23	11	......
" " " ..	217	100	117	864,555	Line of B.&O.R.R., 1 mile W. of Piedm't		
George's Creek Coal & Iron Co......................	1,550?	200	1,350?	1,144,260	25	9	Both.
Maryland, or Savage Mountain Coal Co..............	500?	5	495	28,250	26	8	"
National Coal Co...........	85	7	78	41,989	24	10	Cumb.
Central Coal M. & M. Co....	793	235	558	1,289,478	26	8	Both.
Atlantic & George's Creek Coal Co..................	54	30	24	163,858	27¼	6¼	Piedmont.
American Coal Co..........	878	216	662	1,186,433	26	8	Both.
" "	241	58	183	821,682	29	5	Piedmont.
Davis & Rieman...........	144	....	144	....	......	......	......
Piedmont Coal & Iron Co..	140?	70	70?	397,957	23¼	5¼	Piedmont.
Barton Coal Co............	70	38	32	211,498	29¼	4¼	"
" "	110	....	110				
Potomac Coal Co...........	94	58	36	322,579	29¼	4¼	"
Swanton Mining Co.........	140?	68	72?	371,664	29	5	"
George's Creek Mining Co..	200?	35	165?	194,094	31¼	2¼	"
Franklin Coal Co......... ..	300?	122	178?	672,248	32¼	1¼	.....
S. P. Smith (Hoy Tracts)....	8	....	178	....	......	......	......
" "	110	....		....	......	......	......
" "	50	25?		....	......	......	......
" "	35	....		....	......	......	......
Humbertson Tract.........	49	....	49	....	......	......	......
Jacob's Tract.............	24	....	24?	....	......	.....	......
Hixonbaugh's Tract........	100	....	100?	....	......	......	......
Percy Tract (Boston owners)	80	....	80?	....	......	......	......
Kite Tract.................	25	....	25?	....	......	......	......
	17,282	2,525	14,757				

From the number of acres worked out according to Mr. Hodge's Report in 1869 (2,525), and the total production at that time (12,953,317 tons), it appears that the average production per acre was 5,130 tons. The original area of the great coal-bed was but 17,282 acres, or 27 square miles, and there were, in 1869, 14,757 acres, or 23 square miles of this coal remaining, which, if it is mined on the same wasteful system, will produce 75,703,410 tons. At the same rate of production as last year, this would be exhausted in less than 33 years. With the consolidation of the coal companies, the business will be

conducted on a better system in every respect. But, while a larger production of coal per acre may be looked for, the market for Cumberland coal is increasing rapidly, so that, in every point of view, it is evident that the deposit is a limited one, and the exhaustion of the great bed of Cumberland coal at no very remote period may be anticipated. We are now using in America the best coals we have, anthracite, semi-bituminous, and bituminous, and wasting them as though they were inexhaustible, and of but little value. The time may come when such coals will be among the luxuries.

The Present Proprietors.

The Consolidation Coal Company has become the proprietor of more than one-half of the entire Cumberland coal-field, having acquired the property of the Cumberland Coal and Iron Company, their railroad, etc., as well as other lands, since the date of Prof. Hodge's Report. The only other mining companies sending coal to market in 1872, besides the Consolidation Company, are the following, the numbers attached to each indicating the location of their lands on the map accompanying this article, viz.: Hampshire & Baltimore Coal Company, 25 and 10; Franklin Coal Company, 1; George's Creek Mining Company, 1½; American Coal Company, 3; Swanton Coal Company, 2; Piedmont Coal Company, 4; Barton Coal Company, 3; Potomac Coal Company, 5; George's Creek Coal and Iron Company, 10, 11; Borden, 15, 16, 17; Midlothian, 14; Maryland, 6, 11; Atlantic and George's Creek, 6½; and the New Central Coal Company, 8.[1] The Consolidation Coal Company, who now are the proprietors of so large a portion of this coal-region, own the other lands and mines not above enumerated, one of the finest bodies of coal-lands in the country, owned by a single corporation. They also own and operate the railroads through this coal-region from Cumberland to Piedmont, and

[1] Production in 1873: Consolidation Coal Company, 548,484; Maryland, 304,-124; George's Creek Coal and Iron Company, 302,264; New Central Coal Company, 285,146; American, 265,549; Hampshire and Baltimore, 197,927; Borden Mining Company, 178,460; Atlantic and George Creek, 115,071; Franklin, 110,982; Potomac, 80,150; Virginia, 77,582; George's Creek Mining, 72,151; Piedmont, 67,829; Swanton, 54,493; Blaen Avon, 12,552; New Reading Coal Company, 1,337: total, 2,674,101 gross tons.

from the former place to their mines, lately the Cumberland Coal and Iron Company's.

The other Coal-Seams.

The following section of the upper coal-measures of this district was taken by Prof. Philip T. Tyson, from survey and actual measurement in 1852. It shows the coal-seams above the Great Bed:

Feet above tide.	No.	Character of Rock.	Thickness.		Feet above tide.	No.	Character of Rock.	Feet.	In.
	28	Shale	1	6			*Coal* J. Sewickly	3	6
	27	*Coal* l.	2	0	1,900	14	Fire-Clay	3	0
2,050	26	Shaly Sandstone	19	0		13	Shaly Sandstones }		
	25	Shale	23	6		12	Micaceous }	51	0
	24	*Coal* K. Waynesburg	6	0		11	Coarse }		
	23	Limestone and Shale	12	0		10	Shale	42	6
	22	Fire-Clay	18	9		9	*Coal* I. Redstone	4	6
	21	Unknown	8	9		8	Shale	2	0
	20	Iron in Shale	27	3	1,800	7	*Coal*	1	0
1,950	19	Shale	27	9		6	Shale	4	9
	18	Fine-grain Sandstone	8	6		5	*Coal*		10
	17	Shale	2	6		4	Shale	1	3
	16	*Coal*, 2 in. slate j.	4	3		3	Shaly Sandstone	1	0
	15	Fire-Clay	10			2	Shale, ferruginous	4	6
						1	MAIN COAL H. Pittsburg.	14	0

The section taken near the centre of the George's Creek basin, and published by Prof. Ducatel in the Maryland State Geological Report, also shows the same five seams of coal above the Great Bed, measuring, in the ascending order: 4′ 6″, 3′ 6″, 4′ 1″, 6 feet, and 2 feet, in a thickness of 250 feet. At the Hampshire & Baltimore Company's mines, No. 25 on the map, the 6-feet bed is worked to some extent at an elevation of 60 feet above the Great Bed, and produces 6 feet of good coal.

Prof. Tyson also gives the following elaborate section of the Barren Measures, as they are called, in Pennsylvania (lying below H, or the Pittsburg or Cumberland coal-bed), and the lower coal-measures. It is worthy of preservation, for the use of those interested in the region:

The measurements from 670 to 1,120 feet were taken on the Savage River and Potomac. Thence to 1,349 feet on Mill Run, which flows into George's Creek. Thence to 1,443 feet on Laurel Run, which also flows into George's Creek. From 1,443 feet on the southeast face of Dug Hill, at the foot of which is Lonaconing.

Feet above Tide.	*Thickness.*	*Character of Rock.*
1,800	14′ 0″	MAIN COAL, H.
	4″	Bands of Iron-ore.
	11′ 8″	Shale.

Feet above Tide.	*Thickness.*	*Character of Rock.*
	3′ 0″	Fire-Clay.
1,750	1′ 6″	Limestone.
	15′ 6″	Shale.
	29′ 0″	Sandstone, fine grain.
1,700	27′ 6″	Shale.
	2′ 6″	Coal, G.
	4′ 0″	Shale.
	16′ 8″	Shale. Ore No. 20 at its top.
	1′ 0″	Shale ferruginous.
	3′ 9″	Coal.
	1′ 0″	Shale.
	1′ 0″	Coal.
1,650	2′ 6″	Ore Nos. 17, 18, and 19, in Shale.
	3′ 0″	Ore No. 16 in Fire-Clay.
	6″	Shale.
	1′ 0″	Coal.
	7″	Ore No. 15 in Shale.
	2′ 0″	Ore-balls in stratum of Fire-Clay.
	6″	Shale.
	1′ 6″	Coal.
	2′ 6″	Shale.
	5′ 6″	Ores No. 13 and 14 in Fire-Clay.
	1′ 6″	Sandstone.
	6′ 6″	Ores 12, 11, 10, 9 in Shale.
	6′ 6″	Shale with ore-balls Nos. 8 and 7.
	7″	Ore No. 6.
	4′ 3″	Shale with ore No. 5.
	6″	Coal.
	6″	Ore No. 4 in Shale.
	1′ 6″	Coal.
	2′ 0″	Shale.
	2′ 3″	Shale and Coal together.
	2′ 2″	Ore No. 3 in Shale.
	2′ 1″	Coal.
	6″	Shale.
1,600	2′ 8″	Ore No. 2 in Fire-Clay.
	4′ 10″	Ore No. 1 in Shale.
	2′ 6″	Ore in Shale.
	1′ 6″	Upper black band Ore. — Undermine in the 8″ Coal and all the Ore above for 4′ will come down. If stacked in rows and self-washed for a month, it will yield 40 0-0.
	8″	Coal.

Feet above Tide.	*Thickness.*	*Character of Rock.*	
1,600	2' 0"	Shaly Sandstone.	
	4' 6"	Shale.	
	2' 6"	Coal, B.	
	3' 0"	Limestone.	
	3' 6"	Fire-Clay.	
	8"	Coal.	
	1' 6"	Shale.	
	1' 6"	Shale ferruginous.	
	1' 0"	Shale.	
	1' 8"	Coal.	
	1' 8"	Shale.	
	1' 6"	Coal.	
	1' 6"	Shale.	
	1' 6"	Coal.	
	2' 8"	Shale, brown.	
	5' 0"	Shale, sandy with balls.	
1,550	3' 0"	Shaly sandstone.	
	4' 6"	Shale.	
	1' 6"	Coal.	
	7' 4"	Fire-Clay.	
	5' 0"	Shales ferruginous.	
	7' 0"	Shale with balls.	
	2' 0"	Shale ferruginous.	
	1' 0"	Shale.	
1,500	39' 0"	Sandstone.	
	15' 0"	Shale.	
	3' 0"	Ore in Fire-Clay.	
	6' 0"	Limestone.	
	2' 0"	Ore in Fire-Clay.	
1,450	10' 0"	Shale.	
	44' 0"	Sandstone.	
1,400	8"	Coal.	
	10"	Shale.	
	2' 2"	Limestone.	
	23' 6"	Sandstone.	
	6' 0"	Shale.	
	6' 0"	Hard black band.	
	6' 0"	Shale very ferruginous.	
	4' 6"	Shale.	
1,350	1' 8"	Coal Shaly.	
	1' 0"	Coal hard.	5' 8"
	3' 0"	Coal good.	
	4' 0"	Sandy Fire-Clay.	
	6' 0"	Ore in Shaly Fire-Clay.	
	6' 0"	Limestone.	

Feet above Tide.	*Thickness.*	*Character of Rock.*
1,300	33' 0"	Sandstone.
	9' 6"	Shale.
	11' 0"	Ore-balls. Marine shells. Balls in Shale.
	2"	Coal.
	6' 0"	Shale.
	2' 2"	Coal.
	14' 0"	Shale.
1,250	4' 0"	Coal.
	25' 6"	Shales. Fire-Clay. Sandstone. Not explored.
	2' 0"	Coal.
1,200	102'	Unknown.
1,150		Coal-crop near top.
		Sandstone at bottom.
	24' 0"	Ferruginous Shale.
1,100		Gray Shale.
		Black Shale.
	2' 0"	
	6"	Six feet Coal.
	3' 6"	
	3' 0"	Fire-Clay.
	6' 0"	Shales with balls of ore.
	27' 0"	Unknown.
	3' 0"	Coal.
1,050	4"	Shale.
	19' 0"	Sandstone.
	8"	Coal.
	20' 0"	Shales. Fire-Clay. Shales. Fire-Clay.
	1' 6"	Coal.
1,000	10' 0"	Fire-Clay.
950	92' 0"	Sandstone (XII.) This rock is constant. It makes the flat summit of the West Mountain; and, north of Savage Creek, has lying on it isolated cubic blocks, fragments of themselves, as large as three-story houses, very remarkable objects.

Feet above Tide.	Thickness.		Character of Rock.
950	3′	0″	Large balls of ore.
900	14′	6″	Shale.
		8″	Shale-Coal.
	12′	8″	Sandstone, thin layers.
	2′	0″	Coal.
	2′	6″	Shale.
850	42′	6″	(Sandstone, etc., not explored.)
	7′	6″	Ore in Shale.
800	88′	0″	(Principally Sandstone. ?)
750	2′	6″	Coal.
	?	?	Shale. Small interval.
	27′	0″	Sandstone, thin-bedded.
	2′	0″	Lowest known coal-bed.
	160′	0″	Principally Sandstone, but not much
550			explored.
	90′	0″	Green Shale of XI.
450	?	?	Gray limestone of XI.

The lower coal-measures of the Cumberland region were described in 1856, by Prof. James Hall, of Albany, New York, from whose report on the Ward Coal Company lands the following facts are derived: The locality examined by him is on the north fork of Jennings's Run, on the easterly margin of the basin or coal-field, and, the general direction of the basin being from northeast to southwest, the strata are all presented dipping to the northwest. The valley of the stream renders accessible the beds of coal, of which the two lower seams are about 20 feet above the level of the stream. The lowest coal-seam is exposed a short distance above the outcrop of the conglomerate, and is composed of two parts, the lower, from 24 to 32 inches, the upper 6 to 8 inches, separated by from 12 to 16 inches of shale. This is called the Bluebough coal-bed.

The next seam is the Parker coal, which lies about 36 feet higher in the series, and measures from 24 to 30 inches. A third seam, called the Powell coal, is found 25 to 30 feet higher than the Parker, and is said to have a thickness of three and a half feet. A fourth seam, known as the Percy coal-bed, lies about 20 feet above the Powell, and is said to be 28 to 30 inches thick. Some 30 feet higher lies a fifth bed, known as the Hall bed, which is said to be four feet thick. There is a sixth bed of coal known as the Rush Run coal, having a thickness of two

feet; and still higher another bed of two feet thick, having immediately above it a bed of iron-ore 14 inches thick.

The great seam of this coal-field is the only one that receives any attention, but the general reader may desire to know these particulars as to other valuable coal-seams in the region. At Piedmont, on the east side of George's Creek, and on the northwest slope of Dan's Mountain, one of the lower seams is opened three feet thick, 100 feet in elevation, and on the west side of the creek and eastern slope of Savage Mountain, at an elevation of 130 feet, and five feet in thickness. Also, on the Virginia side of the Potomac, on the north slope of what is termed New Creek Ridge, the Big Seam is 15 feet thick, with four smaller ones below it.

These sections show the great thickness of the coal-measures in this district, and that the whole system is represented up to the highest valuable coal-seam, but without the overlying second series of Barren Measures found near the Ohio River. The coal-beds of the upper coal-measures are here in their greatest magnitude, the seams found in the Barren Measures are also enlarged, and those of the lower coal-measures are small, being split up into a large number of thin seams. The general series of the coal-beds is similar to that previously described in Somerset County, Pennsylvania, and at Connellsville, and to that which will be hereafter given in the northern part of West Virginia.

The Cumberland coal contains from 13 to 19¾ per cent. of volatile matter, from 72 to 83 per cent. of carbon, and is a true semi-bituminous coal. The coal is all taken from the miner, fine and coarse, none of the coal mined being rejected or left in the mine, as is done with some bituminous coals, and there is very little if any screening done, to separate the fine from the coarse or lump coal. It mines out in large masses, many of them as large as a man can handle, and at the pit's mouth there is very little fine coal. The coal is beautiful in appearance, of a jet-black and glossy appearance; but these large masses are very friable, and become very much pulverized in the course of transportation and handling. This is in a measure compensated in burning it for steam-purposes, by its melting and crusting over; and, when partially coked, this crust can be broken up with a poker and burnt again like lump-

coal. But lump-coal is more marketable, and no coal is stocked at any of the mines at Cumberland, or at Baltimore, on account of its being reduced to fine coal by the action of the atmosphere; hence no coal is mined in the winter, after the canals are closed. When orders are received, the coal is mined, put into the cars, and shipped, and, when there are no orders, no mining is done. This irregular work adds to the expense, as miners must have wages sufficient to compensate for these periods when they are without work. The Cumberland basin is quite remote from tide-water, where its market is found, the distance from Baltimore to Cumberland, the east end of the region, being by the Baltimore & Ohio Railroad, 178 miles, and 206 miles to Piedmont, the west end, where the largest portion of the coal is received.[1] This road is the principal avenue to market, the only other being the Chesapeake & Ohio Canal from Cumberland to Alexandria, Va., 191 miles.

The principal market for Cumberland Coal is in the city of New York, either coastwise in vessels, from Alexandria and Baltimore, or by barges, by way of the Chesapeake & Delaware Canal, and the Raritan (New Jersey) Canal, 240 miles. The work, including the transportation, is all done very cheaply. The cost of the long railroad-carriage mentioned is reduced to the minimum rate in this country, and, after being transported these long distances, the coal is sold at so low a price as to afford no such profit as the capital invested should receive. Two things are to be regretted about the Cumberland coal-region: the waste of coal in mining, and the very small dividends received by those who expend so much money, enterprise, and hard work, in furnishing so good a coal at so low a price to ungrateful customers. The statistics of the trade will be given, with others, at the close of this volume. This region was first developed by the completion of the Chesapeake & Ohio Canal, in 1850, to Cumberland; the Baltimore & Ohio Railroad, to Piedmont, in 1842; the Cumberland & Pennsylvania Railroad from Cumberland to Piedmont; the Cumberland Coal & Iron Company's Railroad from Cumberland to their mines; and the building up of a coal-trade exceeding two millions of tons per annum within thirty years.

[1] The distances from Cumberland and Piedmont to the various mines are given on page 250.

The dimensions of the region seem small when compared with some of the extensive coal-regions of other States, but it has the great requisites of a successful coal-region in a good quality of coal, in sufficient quantity to supply a large market; it is produced and carried cheaply; it has abundant transportation by rail and water; it has the market of New York and of the whole Atlantic coast. It might be added that the coal has always been sold at so low a price, compared with its cost, that the operators must be regarded as better friends of the manufacturers and other coal-consumers than of themselves and their stockholders.

As we proceed westward from the Cumberland coal-basin, the axes of disturbance occur at much wider intervals, forming broader undulations, attended with more gentle dips. Those of the Cumberland or Frostburg basin have a comparatively steep inclination of their strata. It was the depth thus given to the basin, even when it contracted it to an inconsiderable width, that has conferred on it the great economical advantages it possesses; for by this means the bottom of the trough was rendered sufficiently low to admit of the whole of the rocks belonging to the productive coal-measures, both of the lower and upper series, without towering to such an altitude as to be exposed to the destructive torrents which have robbed so large a portion of the area of this coal-region of the coal-seams which once spread continuously over its surface (W. B. Rogers).

W. B. Rogers's Analyses of Virginia Semi-Bituminous Coals, Hampshire & Hardy Counties and Cumberland, Maryland.

MINE.	PLACE, ETC.	Carbon.	Volatile Matter.	Ash.
Brantzburg	N. B. Potomac, 2 miles mouth Savage	72.40	19.72	7.88
Olive	12 feet seam	79.08	16.28	6.64
Sigler's Mine	Westernport, Maryland	82.60	15.76	2.64
Lonaconing, Maryland	Cumberland 12 feet seam	77.48	19.37	8.20
Macdonald's	Abraham's Creek, 3d seam	74.00	18.60	7.40
Turnpike	1 mile from top Alleghany	77.12	19.60	8.28
Kitzmiller's	Hardy County	79.76	15.48	4.76
Stoney River	" " lower seam	79.16	15.52	5.32
Michael's	Near Abraham's Creek	72.40	15.20	12.40
Stoney River	1 mile north of Turnpike	88.86	18.28	8.86
W. R. JOHNSON'S ANALYSES. 1844.				
New York & Md. Min. Co.		78.50	12.81	12.40
Neff's Cumberland		74.58	12.67	10.84
Easby's Coal in Store		76.26	14.98	8.08
Atkinson & Templeman		76.69	15.53	7.88
Easby & Smith's		74.29	15.52	9.30
Cumberland Navy Yard		70.85	14.87	14.98

For a further account of the peculiar and valuable qualities of semi-bituminous coal, the reader is referred to the portion of the chapter on the Blossburg region, from page 150 to 161, especially to the results of the government experiments, given in the table on page 160.

Maryland, west of the Cumberland Region.

The triangular corner of MARYLAND, west of the city of Cumberland, is traversed in a northeast and southwest direction by the following seven ranges of mountains: Dan's Mountain forming the east, and Great Savage Mountain the western boundary of the Frostburg or George's Creek coal-field; then in succession the Little Savage, the Meadow, and Negro Mountains, Keyser Ridge, and Winding Ridge, which brings us to the Youghiogheny River. Besides these, there are two shorter ridges, Middle Ridge, between the two Savages, and Hoop-pole Ridge, a southwestern branch of the Little Savage.

The Great Savage Mountain, or Big Backbone, as it is frequently called, is not the dividing ridge, separating the eastern from the western waters. The Savage River, reënforced by two streamlets, the Middle Fork and Crab-tree Creek, makes its way through it, to empty itself into the Potomac. A spur of the Great Savage, known at the head of Deep Creek as the Little Backbone, is the true dividing ridge, the waters of this creek flowing west, and those of Crab-tree flowing east, though taking their rise only a few hundred yards apart.

Pursuing the National Road across Savage Mountain in a northerly direction, the coal-rocks disappear at the summit of the ridge. After crossing the Little Savage Mountain and Meadow Mountain, the coal-rocks reappear in another coal-basin between the latter and the Negro Mountain, the centre of which, however, and more available portions, belong to the State of Pennsylvania, forming the first sub-coal-basin of that State lying between the Alleghany and Negro Mountain.

The Youghiogheny, which takes its rise in the southwest angle of Maryland, cuts through this coal-formation longitudinally from south to north, and exhibits the coal-rocks from within a few miles of its head to its junction with Castleman's River, in Pennsylvania. The eastern slope of the Briery

Mountain, which forms the western limits of the State, is also composed of coal-rocks, supporting a very productive soil.

The principal tributaries of the Youghiogheny in Maryland are on its east side, from south to north Cherry-tree Fork, Little Youghiogheny, Deep Creek, and Bear Creek, and on the west side, Muddy Creek, all of them having a pretty rapid fall.

It will be noticed that the area of the part of the coal-field of Maryland west of the Cumberland basin is small, and parts of it are cut out by the valley of the Potomac River, which forms the line between it and West Virginia; also other portions by the valley of the Youghiogheny River, which runs through it northward; and other portions by Deep Creek, its large branch on the east side. From the Cumberland coal field westward there is quite a wide region of the east escarp ment of the Alleghany Mountain, which is destitute of coal, and then the high uplifts or anticlinals of Negro Mountain cut out other large portions of the coal-field. There appears to be no development of the coal-trade in the regions of Maryland west of Piedmont, the market being entirely supplied from the Cumberland or Frostburg region.

XII.

WEST VIRGINIA.

The coal-field of West Virginia comprises the large territory lying between the western limits of the State and an irregular line of mountain-ranges, on its eastern side, nearly coinciding with the eastern front of the Alleghany, the Greenbrier, and the Great Flat Top Mountains. It is an enormous area of nearly horizontal strata, with geographical features of great simplicity. Its surface is undulating, and toward the southeastern limits mountainous, but the hills rise in gently-swelling outlines, and no very prominent peaks tower in acute and ragged lines, to denote that the strata have been subjected to violent convulsions and upheaving forces. A geological map would represent about 16,000 square miles of its area as of the Carboniferous age, but the reader should not thereby understand that every portion of it contains valuable seams of coal in a position accessible and convenient for mining. Only a small portion, too, of this great coal-region is developed by mining in a few localities and to a limited extent. Its importance, therefore, like many others of our vast mineral districts, is in the future, and the account here given of it is general.

A State geological survey was begun under the direction of William B. Rogers, who made five annual reports of progress for the years 1837, 1838, 1839, 1840, and 1841, after which the work was abandoned in an unfinished condition. These reports were published in pamphlets, and the books are very rare; their more important and interesting portions, relating to the coal-deposits, are here reproduced, and arranged in connection with materials derived from other sources.

Preliminary General View.

The general system of the coal-measures is the same as that of Pennsylvania, with such changes in the thickness of the various strata of sandstone, shale, limestone, and coal, as might be expected from the distance and the extent of the regions. The coal-rocks show the same divisions into the conglomerate base (which in this State assumes great varieties, embracing various strata of shale and some coal-seams): 1. The lower coal-measures; 2. The barren-measures; 3. The upper coal-measures, and 4. The upper shale and sandstone-measures, which are also barren of coal.

1. The lower coal-measures have a thickness of about 250 feet or more, and, in a section taken across the northern part of this State, they contain five seams of coal, four of which are represented as only from one to two and a half feet thick, and the other, or upper one, from three and a half to four feet. But farther south, on the Kanawha River, the coal-seams of the lower coal-measures are developed in number and size, scarcely equalled in any part of the Alleghany coal-region.

2. The highest stratum of these lower coal-measures is a coarse sandstone, called in Pennsylvania the Mahoning sandstone, which varies in thickness from 20 to 100 feet, and is generally about 75 feet thick. Resting upon the Mahoning sandstone are the Barren Measures, which Rogers represents as 466 feet thick in West Virginia, with three thin seams of coal, the lowest six inches to one foot thick and poor, the next 2½ to three feet, and the other two feet. It also contains eleven different beds of limestone, of which the upper one is 40 feet thick, the lower one 10 feet, and the others about three feet. There are altogether in these Barren Measures 41 alternate layers of shales, sandstones, limestones, and coal.

3. The upper coal-measures seem to be the more important in the northern part of West Virginia, on account of the greater size of the seams, and their accessible position. They are 250 feet and upward in thickness, and include four fine seams of coal, the first or lowest of which is the celebrated Pittsburg bed, nine feet thick; the second, 22 feet higher, is 3½ feet thick; the third, 28 feet higher, is a 5½-feet seam of

good coal; and the fourth, 188 feet higher, is seven feet—in all 25 feet of coal in these upper measures alone. There are also no less than nine separate beds of limestone, measuring in all 50 feet 10 inches in thickness.

4. Above the upper coal-measures of West Virginia are piled up a second series of Barren Measures of considerable thickness, consisting of alternate layers of shales and sandstones, some of the layers 20 feet in thickness, and a few thin layers of limestone, but no coal-seams. The upper and lower productive coal-measures, with the intermediate Barren Measures, are together about 1,000 feet in thickness, besides the upper Barren Measures and the conglomerate base.

In a business aspect there are three lines of observation of this coal-region. The first is along the Ohio River, from the Pennsylvania and West Virginia line, 45 miles below Pittsburg; thence by the river to the mouth of the Big Sandy, the Kentucky line, a distance of 279 miles by the river, passing first from the Pennsylvania line to Pipe Creek, 62 miles through the upper coal-measures; thence to Carr's Run or Pomeroy, 140 miles through the overlying rocks; and thence 77 miles to the Kentucky line, through the barren coal-measures. At Wheeling, and for 14 miles down the river, the cliff or bank presents an uninterrupted bed of bituminous coal upward of six feet thick, of such a quality as to furnish fuel for all the dwellings and manufactories of that enterprising and prosperous town. Above are two thinner beds of an inferior value. Associated with these seams of coal is a bed of limestone of upward of 20 feet in thickness. The second line of observation is along the Baltimore & Ohio Railroad which crosses the northern part of the State, passing from the east through the Potomac basins of the upper coal-measures in the Cumberland or Frostburg (Maryland) region, which extends across the Potomac into West Virginia; thence through the various basins formed by the undulations to be hereafter described, to Grafton, whence there are two railroads westward: one due westward, crossing the Monongahela at Clarksburg, and thence to the Ohio River at Parkersburg; the other northwestward, crossing the Monongahela at Fairmount, and thence down Grave Creek to the Ohio River, and thence up the river to

Wheeling. Both these branches enter the main body of the upper coal-measures near the crossings of the Monongahela above named, and traverse them to the Ohio, the points at present most productive of coal being the two crossings mentioned. There are detached patches of the upper coal-measures east of the point named. At Clarksburg and northward, down the valley of the Monongahela, there exists one of the richest coal-deposits in the State. One of the beds in some places in the neighborhood of this town is from 10 to 12 feet in thickness, below which is a thinner seam of a more highly-bituminous character. From some distance above Clarksburg they may be followed with scarcely any interruption throughout the whole valley of the Monongahela northward to Pittsburg. Ascending the Tygart's Valley River southward, the coal diminishes in thickness and valuable qualities. Coal is also found, though in less considerable quantities, in the valley of the Little Kanawha. Near Hughes River, one of its tributaries, it is very abundant.

A coal containing much less bituminous matter occurs immediately west of the eastern front ridge of the Alleghany, in Hampshire County, lying in five successive tiers, and extending for many miles along the borders of the Potomac. This district has been fully described in the chapter on Maryland.

The third line of observation is that on the Kanawha River, which is a navigable stream for 70 miles, and for a distance of about 30 miles from Charleston to the Great Falls of the Kanawha, affords along its banks a fine display of the lower coal-seams in their maximum size and number. This Kanawha region is soon to be traversed by one of the main east and west thoroughfare lines of travel, called the Chesapeake & Ohio Railroad, by which its mineral wealth will be developed.

Here at least three great seams of coal display themselves almost continuously for a distance of about 12 miles, stretching in parallel and nearly horizontal bands along the almost mountainous cliffs forming the boundaries of the rich and lovely valley of the Kanawha in the vicinity of Charleston. On the Great Kanawha the exposure of coals is one of the most extensive and valuable anywhere in the United States, and it is in the immediate vicinity of the Salines. On the Gauley and

other rivers the beds of coal are frequently brought to view, and they spread with the beds of sandstone in nearly horizontal planes, over almost the whole of this broad region.

Coal River enters the Kanawha 12 miles below Charleston. As far up this branch as Brier Creek, on Coal River, 23 miles above its mouth, there are four or five seams of coal seen in the hill-sides. Several varieties of coal are produced in West Virginia, the common bituminous and cannel coals, splint or iron-smelting coal on the Kanawha, and a vein of Albertite in Ritchie County, similar to that in New Brunswick. With this brief preliminary description of the series of rocks of which this great coal State is made up, and the most important places where the coal is exposed, the reader will be the better able to see, in reading the following graphic description of the structure of the coal-field, how its several parts will occur on the surface in various localities. The account previously given of the remarkable features of the coal-field in the southern part of Pennsylvania will also be borne in mind, especially the great anticlinal uplift of Negro Mountain which runs into Western Maryland, and Chestnut Ridge and Laurel Hill, which extend across the State line into West Virginia, the latter crossing the Cheat River. But the Virginia survey was left in so unfinished a condition,[1] and without a geological map, or reports of the geology of each county, that no very accurate description can be given of every portion of the State covered by the various seams of coal, or what parts are destitute of coal from denudation or anticlinal uplifts. The account, however, is probably as minute as the present importance of the region in the coal-market demands.

GENERAL SKETCH OF THE STRUCTURE OF THE COAL-FIELD.

Prof. William B. Rogers, in the Geological Reports of the State of Virginia, gives substantially the following lucid and interesting description of the general features of the great coal-region which covers nearly the whole of what is now the

[1] Reports of the Geological Survey of Virginia, by W. B. Rogers; first, 1836, 143 pages; first and second, 1838, Philadelphia, 87 pages; third, 1839, Philadelphia, 4to, 52 pages; fourth, 1840, Richmond, 8vo, 161 pages; fifth, 1841, Richmond, 8vo, 132 pages. The final report never was published.

State of West Virginia. "It is given," he says, "in the hope that the more important relations of its strata as to direction and position may be clearly perceived, and that any erroneous views as regards the general extension of the more important coal-seams may be no longer entertained. A little attention to this description of the configuration of the strata included in this vast basin, and the various modes in which they are exposed by that noble river, the Ohio, which pursues its way along and through them, will give the reader a general plan or pattern elucidating the great features of the structure, not only of the coal-region of this State, but in a measure of the whole Alleghany region of which West Virginia is the central portion. The country east of the coal-region in the old State of Virginia is characterized, like the corresponding locality in Pennsylvania, by numerous successive and generally abrupt undulations, forming prolonged lines of parallel anticlinal and synclinal mountains and valleys alternately arranged upon its surface. We need, therefore, not be surprised to find similar variations in the positions of the strata continued for some distance beyond the margin of the region in which the geologically higher and more western groups of rocks appear. These anticlinal axes met with in the West Virginia coal-region preserve a parallel direction with those of the Appalachian belt east of them, and give rise to ranges of mountains less elevated above the general level of the surrounding region, and broader and less abrupt in their declivity, than the ridges formed by the more steeply-inclined strata of the Appalachian or eastern region. Along the summits of these broad mountains the mantle of rocks appertaining to the coal-formation which once evidently continued in its extension over the inferior strata has been more or less removed; and thus in their undulating tops, and in their profound ravines and river-gorges, the strata of rocks below the coal-measures are not unfrequently deeply and extensively exposed. The destructive rush of waters, after tearing away the stouter materials above, has met with less resistance from the soft shales and sandstones forming the interior mass of these broad ridges. Hence would appear to have originated the deep valleys and abrupt hills by which this country is characterized, and hence the deeply-scooped channels of those

streams which are permitted not merely to pass through but to meander for great distances along the central line of the axis, and in the very heart of the mountains whose interior structure they thus contribute to disclose.

"Over wide districts in the western part of this region the few low undulations which occur ultimately become lost in the gentle and almost imperceptible inclination of the strata toward the valley of the Ohio. Here even the uppermost of the rocks below the coal-measures are no longer to be met with anywhere on the surface, or in the deepest natural or artificial exposures that exist. The rocks belonging to the principal coal-measures in their turn also become buried as we approach the Ohio, in the region of Parkersburg and Point Pleasant, giving place upon the surface to the Barren Measures, consisting of shales and sandstones, either destitute of coal or containing it in thin and variable beds. These gently-sloping strata thus gradually depressed, again rise to the surface as we proceed still farther to the west, thus bringing into view over a wide and affluent belt of country, in the neighboring State of Ohio, the counterparts of the lost coal-seams and their associated beds of sandstones, slates, shales, iron-ores, and limestones, in an order the reverse of that in which they had been seen to disappear in West Virginia some distance east of the Ohio.

"As necessary to the general picture of this wide-spread series of rocks, it may be added that beyond this belt of productive coal-measures in Ohio, as we descend to the valley of the Scioto, we come in view of a group of underlying east-dipping sandstones, slates, and limestones, corresponding to the upper formations below the coal-measures, on the east side of the coal-region; so that, comprehending in one wide view the whole series of strata comprising and lying at no great distance beneath the coal-rocks of this wide region, and leaving out of consideration the undulations previously alluded to as occurring toward the eastern margin of the tract, we are presented with the imposing scene of a vast synclinal trough or basin spreading from the eastern escarpment of the coal-rocks in West Virginia entirely across the State, and the east half of Ohio, and terminating there in a similar escarpment, in which the rocks are seen inclining toward the east to meet their counterparts dip-

ping in an opposite direction in West Virginia. It is a little westward of the centre or lowest line of this enormous basin that the Ohio River pursues its course for most of the distance in which it forms the western boundary of the State of West Virginia.

"But another feature is yet to be introduced to complete the general outline of this interesting region. The eastern and western margins of this basin, though nearly parallel about midway of its length, gradually approach each other as they extend toward the north, and thus bending round, the former in Pennsylvania, the latter in Ohio, at length actually coalesce and form the head or northern termination of the trough. As a result of this configuration it will at once be seen that along this northern boundary of the basin in Northern Pennsylvania the coal rocks must have an inclination toward the south or in the direction of the length of the vast trough, while the strata underlying them beneath this northern escarpment will be seen dipping beneath the basin in a corresponding direction. Fortunately for the resources of the valuable though small tract, including the three counties lying between Pennsylvania and Ohio, and now called "the Panhandle," this northern termination of the trough takes place at no great distance north of where the territory of West Virginia begins. So that the Ohio in its course along the western margin of that tract intersects the southerly-dipping strata in a direction highly favorable for the development of their rich mineral contents, and exposes along the West Virginia, as well as the Ohio shore of the river, nearly all the seams of coal, and beds of limestone and other valuable materials, required to complete the series of strata appertaining to the vast coal-basin through which it flows. From this general outline of the great coal-field of which West Virginia possesses so large a share, it will at once be seen that, leaving out of view the numerous important undulations of the strata before referred to, the higher rocks in the series present themselves successively, dipping beneath the surface as we recede from the margin of the basin toward its middle, from whatever point of this margin we may take our departure. Each stratum of the vast series of the coal-measures may in truth be regarded as an immense oblong bowl or

trough, whose longer diameter has a direction nearly northeast and southwest, terminating at the northern end, near the Ohio and Pennsylvania line, north of Steubenville, and gradually widening in a somewhat oval form as it passes through Virginia and Ohio. Near its widest part, it is obvious, the Virginia and Ohio portions of the margin would be parallel to each other, and to the longer diameter, and would therefore have a direction from northeast to southwest, but, in the progress of its expansion, all the directions between that of its northern end and the one just specified would successively obtain; so that, following it along the eastern margin, we should have it southeast and northwest, south and north, southwest and northeast, and perhaps within the limits of Virginia, approaching Kentucky and Tennessee, west-southwest and east-northeast. We may, therefore, regard a series of such bowls, similar in form, and fitting the one within the other, as giving a general representation of the stratification of the entire region we are considering, neglecting for the present the irregularities occasioned by the undulations in the neighborhood of the eastern margin. Bearing in mind this inelegant but perhaps not useless illustration, it will at once appear that a river like the Alleghany entering the northern margin of the basin, and flowing entirely through it, will penetrate in succession each of the inner bowl-shaped strata on the one side, and then continuing as the Ohio, passing across the innermost, and therefore the uppermost of them all, will again penetrate the same beds, but in an inverted order—and if, as in the case of the Ohio, we suppose it to enter "the Panhandle" of West Virginia, near one of the extremities of the oblong trough, and to flow nearly along but a little west of its central line, we shall have exposures of all the strata from the northern margin to the highest bed of the series, those only excepted which, forming the very innermost and uppermost of the concentric strata, present their western margin to the east of the valley of the river. These, as is really the fact, would be found capping the hills at some distance eastward of the river, and presenting both their eastern and western margins on the Virginia side."

I. *The Ohio River District.*—To complete the application of

this rude analogy to that portion of the great trough of coal-bearing strata through which the Ohio flows, the varying developments of the rocks caused by its frequent and important changes of direction claim also to be considered. If, while flowing through the highest or innermost of the strata accessible in its general course, and thus pursuing a direction nearly from northeast to southwest, it should be diverted from this line so as to take a direction toward the west or northwest, it is obvious that this would lead it away from the inner and higher strata, and carry it across some of the subjacent beds; while a change in the opposite direction would convey it into still higher strata lying to the east, and, if continued for a sufficient distance, might carry it through them to pass into the Eastern or West Virginia sections of the lower strata. It is thus that the river in that part of its course extending from near the northwest corner of Tyler County to the bend a little above Marietta, flowing nearly in the central line of the trough, exposes only the upper strata, but, bending toward the northwest as it approaches Marietta, it displays strata a little lower—and thence, pursuing a direction nearly parallel with that first mentioned, it passes Parkersburg in a line several miles west of what may be regarded as the axis of the trough, still continuing to display nearly the same rocks as are met with at Marietta, until, by another and more important flexure to the northwest below Letart's Falls, it plunges more deeply still into the strata west of the middle of the trough, bringing to light, in a position sufficiently elevated above the river to be productively mined, the important coal-seam wrought on the Ohio side, and known as Pomeroy's Seam. Continuing with numerous flexures its general southwestern course as far as Burlington, and keeping very nearly in the same rocks, the coal of which is again exposed below Gallipolis, it bends around to take a direction bearing it across the western portion of the basin, after which traversing in succession lower and lower strata of the coal-measures, and presenting a noble development of rich coal-seams and iron-ores on the Ohio and Kentucky sides, it emerges from the basin near Portsmouth, and pursues its way through the Appalachian strata lying to the west.

In a subsequent report, Prof. Rogers again had occasion to

refer to the strata displayed on the Ohio River, from the Little Beaver River, in Pennsylvania, to the mouth of the Big Sandy, at the Kentucky line. As it is an important locality, this account is also given. At the northern extremity, near the mouth of Little Beaver, the Ohio River flows in the inferior part of the lower coal-group, the outcrop of which is farther toward the north. Descending the river from this point to the mouth of Fishing Creek, the dip of the rocks is toward the south. Throughout this distance, the course of the stream deviates but little to the west or south, while the principal diameter or axis of the great coal-basin, having a direction more nearly approaching to northeast and southwest, is prolonged from its northwestern termination in Pennsylvania, in a direction lying to the east of this reach of the Ohio. The river is thus made to approach this central line as it descends toward Fishing Creek, and is there near but a little west of the axis or centre of the basin. Below this point, assuming a direction more toward the west, it continues to flow nearly parallel with the axis, though a little west, as far as the bend below Mill Creek, in Jackson County. It now, by a sudden turn, penetrates some distance into the western side of the basin, and, the rocks having a dip toward the axis, that is, toward the southeast, the strata, which, during its previous course, were buried below its bed, are now seen in succession emerging to the surface. Resuming its southwesterly course at Kerr's Run, and preserving that general direction as far as Guyandotte, it continues to expose nearly the same strata, appertaining to the western side of the basin, throughout the whole distance. Then, bending away to the west, it enters the lower coal-group about three miles above the mouth of Big Sandy, on the southern boundary of West Virginia, whence, taking a northwesterly direction, it passes directly across the western side of the basin, and finally, a few miles above Portsmouth, in Ohio, passes beyond its margin. It is obvious, from the sketch of the general directions of the Ohio in its passage longitudinally through the basin, that it presents a line of observation of great interest, comprising nearly the whole of the strata of the coal-measures.

General Description of the Coal-bearing Rocks of West Virginia, and their Seams of Coal.

Prof. Rogers gives the following description of the first of the series of rocks immediately associated with the slates, sandstones, limestones, and coal-seams, comprehended under the denomination of the "coal-rocks." This formation, strongly contrasted, in its general aspect and composition, with those which lie immediately beneath, consists of a group of whitish or light-gray sandstones, generally of a coarse texture, and comprising heavy beds of conglomerate, usually conspicuous for the white, round pebbles of which it is mainly composed.

The same coarse rock, with its attendant pebbles, is found, in a similar geological position, on the backbone of the Alleghany and on the Cheat Mountain, and Laurel Hill, as well as several other minor ridges. It is also well displayed on the summit of the Big Sewell, and various knobs and ridges of the adjacent region, and forms the nearly-level capping of the Blue Stone Mountain and its continuation farther to the southwest. Everywhere along the margin of the great coal-region, this formation may be seen marking the transition from the upper member of the lower series of rocks to the widely-expanded groups of strata with which the coal-seams are associated. It is not, however, to be inferred that at all points it displays the same conspicuous conglomeritic structure, or is developed to the same thickness, for in both these particulars it presents frequent and important fluctuations, passing from a mere mass of large rounded pebbles cemented by siliceous matter, chiefly at their points of contact, to a conglomerate of shot-like gravel, and thence to a coarse and in some cases to a fine sandstone, of even and compact texture, and in thickness varying from a thousand, and perhaps more, to a hundred or even less than a hundred feet. Nor in all cases does it throughout maintain the character of a purely siliceous rock, for instances occur in which bands of slaty sandstone, and even bituminous slate, accompanied by one or more seams of coal, are included between the coarser and more massive strata of the formation. Yet, with all these variations, the general characters of the group, as above described, are sufficiently definite to enable the practised observer

to recognize it when it appears, and its features usually are so well marked that a glance is sufficient for this purpose.

The series of strata above the conglomerate, by which this vast surface is overspread, observe a regular order of superposition, and naturally arrange themselves into four great groups:

1. The first or lowest of these groups, resting on the coarse sandstone or conglomerate described above as constituting the floor upon which the coal-measures are outspread, containing several seams of coal, of which generally one, and sometimes two or three, are of sufficient extent to be of great economical importance, may be designated as the lower coal-group. Occupying the zone next to the margin of the basin, it is sometimes, as on the Kanawha, above Charleston, expanded over a wide area by broad undulations of the strata; and sometimes, as along the western flank of Laurel Hill, made to disappear at no great distance within the basin by the uninterrupted and somewhat rapid dip of the strata toward the northwest. The rocks comprehended in this group, with the exception of the shales and slates immediately associated with the coal-seams, are, for the most part, coarse micaceous sandstones, of a gray and light-brownish color, composing thick and massive layers, but little blended with softer shaly strata; with these are associated beds of limestone, and the most important seams of iron-ore met with in the coal-measures.

2. Next above, we have a series of strata comprising reddish and bluish shales and slates, and gray, bluish, and brown micaceous sandstone, destitute of coal, or containing very thin seams of local extent. Beds of limestone, sometimes numerous and important, are also included in this group in West Virginia, and the remarkable black flint marking the upper boundary of the lower coal-series on the Great Kanawha is found toward its base. This may be called the Barren Measures, or lower shale and sandstone group.

3. Still higher in the series, and occupying a zone still more removed from the margin of the basin, we have a group consisting of gray, brownish, and greenish micaceous sandstones, reddish and greenish shales, and beds of limestone, in some districts of great thickness, together with several seams of coal, and, more especially, the great seam, which shows it-

self so extensively in the neighborhood of Pittsburg, Wheeling, Brownsville, Morgantown, Clarksburg, Pocotaligo Creek, and other points in this coal-region. To this series of strata we may give the name of the upper coal-group.

4. Resting upon this, we find an extensive series of rocks consisting of gray micaceous and felspathic sandstones, together with reddish and greenish shales, more or less calcareous, and containing occasionally thin beds of limestone, but entirely destitute of coal. This, overspreading the central portions of the basin, comprises the highest strata of our great western coal-measures, and may be termed the upper shale and sandstone group. No Permian fossils have been found.

II. *Section of the Three Lower Groups across the Monongahela Valley.*

The following is a summary of Prof. Rogers's detailed section of the various beds of rock and coal-seams included in the lower coal-group, the Barren Measures, and the upper coal-group, taken on a line running across the northern part of the State, commencing at the base of Laurel Hill, of Virginia, the Chestnut Ridge, of Pennsylvania, following the course of Decker's Creek to its mouth, thence pursuing the Monongahela River to the mouth of Scott's Run, and continuing up that run to the termination of the section. From what has frequently been said in regard to the mutability of the strata, as prolonged from place to place, the following section cannot be looked upon as indicating exactly the thickness and character of the different beds, as displayed in a vertical section at any one locality. It will, however, furnish a useful picture of the general features of the different groups of strata, which usually preserve some predominant character over a wide area, and it will also exemplify the extraordinary mineral wealth of the fertile valley of the Monongahela in general. It will be remembered, however, that Northern Virginia having the upper coal-measures finely developed, the lower coal-series, as here represented, is far inferior to the magnificent display of that group farther south, along the Great Kanawha and some of its branches. This section, probably, does not do justice to the coal-beds of the lower group. The series of coal-rocks is given in the ascending order, from the

conglomerate up, the letters being now added to designate the corresponding coal-seams in Pennsylvania:

LOWER COAL-GROUP.

No.		Feet.	No.		Feet.
1	Shale, yellowish gray	6 to 10	12	Sandstone micaceous	5
2	Sandstone, light gray	4	13	Shale and iron-ore	6 to 8
3	Shale not exposed		14	*Coal* C	1 to 2
4	Sandstone, gray	25 to 30	15	Shale	12
5	Shale, bituminous	15 to 20	16	*Coal* D, friable	3½ to 4
6	*Coal* A, friable	1½ to 2½	17	Shale	30 to 40
7	Sandstone and Shale, flaggy	30	18	*Coal* E, thin	1
8	*Coal* B	1	19	Shale	5 to 6
9	Sandstone and Shale, flaggy	40	20	Sandstone (Mahoning) sinks below the bed of Monongahela River below Morgantown	60 to 70
10	Limestone, ferriferous	3 to 4			
11	Shale	8 to 10			

BARREN MEASURES BETWEEN THE LOWER AND UPPER COAL-GROUPS.

No.		Feet.	No.		Feet.
1	Shale	10	22	Limestone	3 to 4
2	Sandstone	20	23	Sandstone, yellow	1
3	Shale	20	24	" micaceous	2½
4	Limestone (water-line)		25	Sandstone, shaly	4
5	Shales	35 to 50	26	Shale, blue	22
6	Limestone	1	27	Limestone	1½
7	Shale	10	28	Sandstone, micaceous	10
8	Limestone	3	29	Sandstone	5
9	Shales	30	30	Shale, olive brown	4
10	*Coal* F, poor	1 to 1½	31	Sandstone, micaceous	½
11	Shale	8	32	Shale	3
12	Sandstone	5	33	Limestone	1½
13	Shales and Sandstone	40	34	Shale	7
14	*Coal*, slaty, G	2½ to 3	35	Limestone, impure	3
15	Shale	10 to 15	36	Shale	10
16	Conglomerate	0 to 6	37	Sandstone, variable	25 to 30
17	Sandstone	25 to 35	38	Shale	3
18	Shale	15	39	*Coal* g	2
19	Limestone	3 to 4	40	Limestone	2
20	Shale	10	41	Shale	14
21	Limestone and Shale	4			

The coals in the Barren Measures attain greater importance along this line than at any other place in this State. There are eleven bands of limestone, in all 24 feet, impure, but yielding lime for agricultural and building purposes.

UPPER COAL-GROUP.

No.		Feet.	No.		Feet.
1	*Coal* H, main or Pittsburg Seam of Upper Group	6½ to 9½	15	Shales	12
			16	Limestone	2
2	Shale	10	17	Shale	2
3	Limestone	12	18	Limestone	5 to 6
4	*Coal* I. Redstone	3 to 4	19	Shale and Sandstone	10 to 12
"	Shale	4 to 8	20	Limestone	7
5	Limestone	6½	21	Shales and Sandstones, 40 + 15 + 35	90 to 100
6 & 7	"	6			
8	Limestone and Shale	5	22	Limestone	5
9	Sandstone	4	23	Shale and Sandstone	20 to 25
10	Limestone	6 to 7	24	*Coal* K, Waynesburg	5
11	*Coal* J, Sewickly	5½		And two smaller seams	2½
12	Shale	5	25	Shales	1 to 20
13	Shales	20 to 25	26	Sandstones	
14	Sandstone	10			

A glance at any map of West Virginia will serve to show that the Greenbrier, the Gauley, the Little Kanawha, the Monongahela, and its great branches, the Cheat River and Tygart's Valley River, and the north fork of the South Branch of the Potomac River, all take their rise from the highlands at the head of the same valley, and, from the opposite courses which they pursue, we are led to conclude that the dividing ridge at the head of these streams in the eastern central part of West Virginia, in Randolph County and those adjoining it, is the highest land west and north of the Alleghany range. Between the head-branches of several of these streams are considerable tracts of glade or table lands, affording tolerably level country, covered with a heavy growth of forest-trees. Also similar tracts occur farther west, between the head-branches of the Gauley, the Elk, and the western forks of the Monongahela.

Every thing bespeaks West Virginia to have been originally an expanded plain which was afterward gently tilted on the east side from the horizontal position, so that its surface and the body of rocks beneath were made to decline with a slight but very uniform depression very gently toward the northwest to the valley of the Ohio. The great inequalities of surface were evidently caused by the furrowing action of a mighty and devastating rush of waters, which, by a rapid draining, scooped out enormous valleys. The parallel position of the strata keeps the coal-seams near the surface over enormously wide spaces of country, while the great depth of the valleys exposes them to the day under positions, for mining, the easiest imaginable.

In this elevating process, which may have occurred repeatedly, and the retreat of the ocean as it ploughed out the present deep valleys of the Potomac, the Monongahela, the Little and Great Kanawha, and the great tributaries of the latter, the Greenbrier, Gauley, etc., it is evident that the elevated summit in Randolph County, near the east side of the State, was a common point of departure for the ocean-currents, and this divides the State, from this central point, into natural divisions like rude segments of a semicircle, which it will be convenient for us to take up and describe in order, beginning on the northeast or Maryland side, and proceeding westward, and thence southward. Bearing in mind the description previously given of

Maryland, west of the Cumberland region, we have first in going westward the Potomac coal-basin of West Virginia, which, crossing Maryland, is represented in Pennsylvania only by the northeastern end in Somerset County, lying east of our six great coal-basins.

Within this basin, as trenched by the north branch of the Potomac, the lofty hills of the Virginia as well as the Maryland side expose to view at various points in Hampshire County the several coal-seams of the lower coal-series, as well as the most valuable of the upper coal-series, being the great Pittsburg or Cumberland seam H, which here attains a thickness of 14 feet of pure coal, and occurs 1,000 or 1,200 feet above the river, with other good seams above this, one of them six feet thick. It is a semi-bituminous coal, as is the case with all the seams of this and the other basins near the eastern margin of the coal-region.

West of the Potomac or Cumberland basin occur also two other basins called by Rogers the middle and western basins, containing two seams of coal, but they seem to be only of local importance. What is called the first sub-basin in the Pennsylvanian survey, included between the axes of the Alleghany and Negro Mountain, next occurs in going westward, but it is, in West Virginia, only a shallow basin, occupied by the lower formation, and in which the coal-measures are not to be found, although it expands and deepens in a northwest direction, and becomes very important through Pennsylvania. In Virginia, it is a wide region of broken and lofty hills traversed by the Cheat River. Lesley, in his Manual, reports the existence of the sub-conglomerate coal-seams on the Youghiogheny and Cheat Rivers, in Northern Virginia, and at Augusta Springs, in Middle Virginia.

The next in a northwest direction, or Kingwood basin, is a narrow, important basin. At Kingwood the basin is six miles wide, but it is much wider at Evansville. It has at least three seams of coal that are known, two of which are worked, the middle one being three feet, and the upper two and a half to three feet thick.

The next or Preston basin is bounded on the western side by the Chestnut Ridge of Pennsylvania, which is called the

Laurel Ridge in Virginia. The Preston and Kingwood basins are both subdivisions of the second basin of Pennsylvania, which, as it extends southward into West Virginia, is divided into two by the development of an anticlinal axis which is called the Preston axis. Each of these basins is about four miles wide. The coal-seams are of variable thickness, sometimes as much as seven or eight feet thick.

The broad, elevated tract, extending under the names of Chestnut Ridge in Pennsylvania, and Laurel Hill in Virginia, near the line, between Preston and Monongalia Counties, is the last of the important axes met with in this part of both States. Following it southwest, the dips of the rocks on both sides of the ridge are seen rapidly becoming less, and the axis becomes flattened out, the lower rocks previously exposed on its back become buried from view, and the ridge itself is entirely lost in the general level of the country. Near the head of Field's Creek, a tributary of Three Forks, there is no mountain, but only a gentle roll or broad wrinkle in the coal-measures.

This second basin of the Pennsylvania survey crosses the Baltimore & Ohio Railroad near Three Forks Creek, nine miles east of Grafton. In a report on the iron-ore and coal-deposits of this locality, Prof. J. P. Lesley gives the following description:

"The principal sandrock, and that one which makes the strongest mark on the shape of the hills, lies everywhere at an elevation of about 400 feet above the beds of the streams, and is doubtless the Mahoning sandstone of the Pennsylvania State Survey; a rock traceable from the upper waters of the West Branch Susquehanna, throughout Western Pennsylvania, Eastern Ohio, and West Virginia, far into Kentucky and Tennessee. It is the top limit of the lower coal system. Above it were deposited from 500 to 700 feet of Barren Measures; and on these again an Upper Coal System. In some regions these rocks are still to be seen. But from other and more extensive districts they have been slowly dissolved and washed away, carrying with them of course the great Pittsburg or Westmoreland bed. This is the simple explanation of its absence above Connellsville, in the Youghiogheny Valley and on Castleman's River, until one reaches Salisbury, in Somerset County, where

a patch remains. There is also a small ribbon of it left at the top of a narrow hill, in the centre of the Ligonier Valley, south of New Florence, on the Pennsylvania Railway.

"The Ligonier Valley lies between two mountains, called Laurel Hill at Johnstown, and Chestnut Hill at Blairsville. The valley between them extends with remarkable straightness and regularity south-southwest for many miles, beyond the West Virginia State line, and beyond the Baltimore & Ohio Railway. Newburg lies exactly on its centre line, just as New Florence does. And as there has been left a patch of the Pittsburg bed, in a high hill-top, on the centre line of the Ligonier Valley, south of New Florence, so at Newburg small fragments of the Pittsburg bed remain in the centre of the valley, at the tops of a series of knobs. It is here 15 feet thick. An inclined plane ascends the first knob south of the town, the coal from which has been already mined out. Trestle-work carries this railway five miles southward to the other knobs, into which gangways have been opened. Still farther south the bed is said to spread out more widely; and there may be an extensive mining-field in that direction. But the country is still covered with forest, and, to open it up, a railway along the Monongahela River, and across the divides leading to the Greenbrier, is projected.

"Newburg, being on the central axis of the Ligonier Valley coal-basin, with fragments of the Pittsburg bed in the tops of the highest knobs, it follows, as a matter of course, that the hills about Newburg are composed of those Barren-Measure rocks which underlie the Pittsburg bed. It follows, also, that the beds of the lower coal system beneath the Barren Measures rise slowly from under these central hills, and appear at railroad grade at the coal-mines two miles east of Newburg; and again at railroad grade two miles west of it, approaching Three Forks Creek.

"The Three Forks Creek flows over a sand-rock stratum 400 feet lower in the series of coal-measures than the Mahoning sandstone. Just underneath this lower sand-rock lies the principal coal-bed of the lower coal system, a bed of fine quality and considerable thickness. Where the sand-rock is worn away, natural rock-dams, furnishing fine mill-power, cross the bed of

the stream, which is then made of the coal-bed itself. Sometimes the stream falls a little faster, or a little slower than the dip of the coal-bed; and, in proportion as this happens, the coal-bed gets a few feet under water-level, or crops out on the hill-sides a few feet above it. Advantage of the latter state of things has been taken at the coke-yard, and a gangway opened, by which coal is delivered directly upon the coke-piles. Two slight changes in the dip throw up the coal (with the rocks above and below it) several yards.

"This low-lying main coal-bed is eight or nine feet thick; but only its lower bench, say four feet thick, affords in all places first-quality coal. The upper benches of the bed are therefore, for the present, rejected. But, if mined on an extensive scale, the whole of the bed can be utilized. Its almost horizontal posture and its regularity give it great value; and, as it spreads underneath all the hills at or near water-level, the quantity is practically exhaustless. It makes a clean, even, silvery coke, sufficiently hard to bear the heaviest burden in the blast-furnace."

The Upper Coal-Measures in West Virginia.

As the upper coal-measures now occur and cover the western part of the State of West Virginia, it will give the reader a better general idea of this part of the State to describe the outcrop line of the Pittsburg seam of coal as given by H. D. Rogers. Beginning where it leaves the State of Ohio on the south, crossing the Ohio River near Burlington between the mouth of the Sandy and Guyandotte Rivers, it curves rapidly toward the east, and sweeps across the Guyandotte near the falls of the river, taking a nearly due east course thence to the Great Kanawha Valley, which it passes at the mouth of Pocotaligo Creek, below Charleston. Before reaching the Kanawha it turns north and pursues an undulating northeast direction parallel to the general course of the Elk River as far as Sutton in Braxton County. From Elk River its general course is north-northeast to the Pennsylvania line, in an excessively winding course, in consequence of the deeply-excavated character of the high, sloping table-land through which it meanders

east of the Monongahela River. In this part of its course it traverses Braxton, Lewis, Barbour, Taylor, and Monongalia Counties, and runs along the western slope of the range of highlands known in Virginia as Laurel Hill. In connection with this eastern rim of the basin of the upper coal-measures it should be borne in mind, as before mentioned, that it extends into Ohio, and the central or deepest part of this great basin coincides nearly with the "Long Reach" of the Ohio River between Marietta, Ohio, which is at the mouth of the Muskingum River, and the mouth of the Fishing Creek, and that it covers "the Panhandle," or three northern counties of West Virginia between Ohio and Pennsylvania. Each of the seams of overlying coal-beds must occupy successively a less and less extent, and the coal-beds of the lower coal-measures must underlie the whole of this vast area at a greater or less depth beneath, the general dip of the strata being westerly. The Pittsburg seam thins out near the south end of the great oval basin, which it occupies to a thickness of little more than three feet, but it would appear that, in this portion of the field on the Ohio side, the Pomeroy seam, which is the lower one of the upper coal-measures, from its size, quality, and facilities for mining, becomes very important.

These upper coal-measures, and the upper Barren Measures above them, are drained by the Monongahela River, flowing northward, the Little Kanawha, running westward, and by the lower portion of the Great Kanawha and Guyandotte Rivers. West of the Laurel Hill the upper coal-measures soon disappear, owing to the rapid dip of the strata toward the northwest.

The line just described as the boundary of the Pittsburg seam of coal is evidently well defined on the ground, and governs the topographical features of the country. The surveyed line of the West Virginia Railroad from Grafton to Charleston conforms to it strictly in all its windings, through the counties of Taylor, Barbour, Upshur, and Braxton, running on the lower coal-measures a little east of the edge of the Pittsburg bed. Thence from Suttonville to Charleston the proposed railroad follows the valley of the Elk River, which, as before described, pursues a course parallel to the line of the Pittsburg bed and the upper coal-measures, to the westward

same formation of hills continues on the westerly side of the valley of the river, while on the easterly it soon reaches the spurs of the Laurel and Cheat Mountains, and rises into lofty eminences with more regularity in their arrangement. The whole face of the country becomes elevated, and between the ranges of mountains we meet with long but narrow strips of level land, here called "Glades." They in some respects resemble the prairies of the West, being clothed with a scanty growth of forest-trees and shrubs, but with a rich vegetable soil. They were, without doubt, once the beds of lakes, and have uniformly a stream of water passing through their deepest portions. The table-lands of Mexico are here represented in miniature. This broken, hilly country is continued throughout the whole region, watered by the Monongahela and its tributary streams. Some tracts of level land are found between the branches of the western fork of the river as it approaches the waters of the Little and Great Kanawha.

On this northwestern side of the Alleghany range the formations abound in sand and clay as their materials. The streams are turbid and tortuous in their courses, and as they descend into the valley they become slow in their progress. The springs are few and small, and readily affected by the droughts of summer. The hills are irregular in their height, and in their arrangement unlike the regular continuous parallel ranges on the east side of the Alleghany, but they are generally very fertile, covered with a rich soil to their very summits, and produce a luxuriant vegetation, such as is found only on rich alluvions, and they are invariably clothed with forest-trees of the most lofty height.[1]

Two or three of the coal-beds above water-level are from 6 to 10 feet thick; and one near Clarksburg, 100 feet below the surface, is said to be 11 feet. These deposits continue to be very abundant about Pittsburg, the outlet of the Monongahela Valley, and spread out east and west of that city, and into Ohio, beyond Steubenville and Wheeling, as before described. Dr. Hildreth gives sections at Morgantown where the hills are 350 to 450 feet high, and where no less than four distinct coal-bed are found between the tops of the hills and the bed of the

[1] Dr. Hildreth, in *Silliman's Journal.*

river. The lowest is in the river, six feet thick, and of very superior coal. The next is 30 feet above, three feet thick, and inferior in quality. The third is 120 feet higher, seven feet thick, and of excellent quality. This is said to be the Sewickley seam, and is 150 feet above the river. The upper seam is 150 feet higher, six feet thick, and is moderately good. At Greensborough, or Geneva, two miles south of the Pennsylvania line, is an 8-feet seam, 50 feet above the river, probably the Pittsburg bed; and 150 feet higher is another, six feet thick, the Waynesburg bed. This section corresponds with what is found all along the river for 95 miles, from the State line to Pittsburg.

On the west or main branch of the Monongahela River, near Clarksburg, the section given by Dr. Hildreth shows two seams of coal, the upper one 10 feet in thickness, sometimes 12 feet, generally of the finest quality, and it is found in exhaustless quantities near the Monongahela River, from this place to Pittsburg. The other seam, at Clarksburg, is 190 feet lower, and is three feet thick. The thickness of the whole series of visible strata at Clarksburg is 393 feet, which is nearly the average height of the hills in the vicinity, and they continue at this elevation for a distance of many miles northward to the vicinity of Brownsville. As we ascend the valley southward the deposits of sandstone-rock become of much greater thickness, and the deposits of coal more thin, and of inferior quality. In the country south of Clarksburg the accessible coal diminishes rapidly both in quantity and in excellence. In the vicinity of this town and north of it, however, down the valley of the Monongahela, we find one of the richest and most abundant deposits of coal in all the valley of the Ohio and its tributaries. Little or no coal is shipped above Brownsville.

To ascertain the development to which any coal-region has attained we must refer to the amount of its coal-trade, and this can be best ascertained from the coal-tonnage of its railroads, canals, and rivers. In so thinly populated a region as West Virginia, with but little manufacturing which consumes coal, the domestic consumption must be but small. The Baltimore & Ohio Railroad traverses the northern part of this State, from the Maryland line westward to Grafton, and from this point there are two branches, one westward to Parkersburg, and the

other northwestward to Wheeling. The coal-tonnage for four years has been as follows: 1868, 165,772 tons; 1869, 269,158 tons; 1870, 248,879 tons; and 1871, 189,763 tons. The coal carried in 1870 was received on this road at the following places, and is used for gas in the Atlantic cities:

Miles to Baltimore.	Tons.
At Clarksburg, 301, on Parkersburg route	102,751
At Fairmont, 302, on Wheeling route	70,536
At Newbury, 266, on main line	72,655
At Tunnelton, 260, on main line	258
At Cairo, 355, on Parkersburg route	1,714
At Austen	728
At Parkersburg	237
Total	248,879

Clarksburg and Fairmont are at the crossings of the Monongahela River on the two branches of this railroad. Newbury, 13 miles east of Grafton, is on the margin of the upper coal-measures, and Tunnelton is on the Great Cheat River. No coal is found on the Baltimore & Ohio Railroad between Fairmont and Moundsville on the Ohio River. It is reported to be 400 feet deep at Littleton and Belton stations.

Cairo is in Ritchie County, 29 miles east of Parkersburg. Here a tramroad leads southward to Hughes River, 15 miles, where the Ritchie mineral, also called Grahamite, is procured, which is sold in Baltimore and New York City for gas-making purposes. It is a substance similar to the Albertite found in New Brunswick, a sort of asphalt, not found in a seam like coal, but in a true vein. It sells in New York at a price but a little less than Albertite. As above stated, 1,714 tons were shipped in 1870. The vein is perfectly vertical, 4½ feet thick, three-fourths of a mile long, and is mined by adits and chambers. Its analysis shows 55 per cent. volatile matter, 42 fixed carbon, and 3 per cent. ashes. This shows but two per cent. less volatile matter than Albertite, the richest mineral that has ever been imported for gas-purposes. It produces from 26 to 28 bushels of a good quality of coke. It is not adapted to be used alone as a gas-producer, but, as a stimulant in the proportion of about 5 per cent., its effects are said to be very extraordinary.[1]

The *Little Kanawha*, north of the Kanawha, and which empties into the Ohio at Parkersburg, is about 100 miles in

[1] For a full description, *see American Journal of Science*, December, 1873.

.ength, its head-branches drinking in the same showers that supply the Gauley, Elk, Cheat, and Greenbrier Rivers. Toward the heads of the streams there are tracts of flat tablelands, affording sites for extensive settlements. About 80 miles from the mouth are falls or cascades of considerable elevation, where the river descends from the mountain-districts into the region at their feet, affording many fine mill-seats. The whole range of the stream is rapid and pretty direct, in time of flood rushing with great violence into and across the Ohio River. There is a marked difference in the rapidity of the current in the streams putting in on the north and south side of the Ohio, the latter being more violent, keeping their mouths free from bars, and affording deep water for navigation. On the north or Ohio side the streams run less rapidly, and rush with less violence to their outlet.

The valley of the Little Kanawha is hilly and broken, containing, however, much rich land in the valleys and along the water-courses, and the hills being covered with a most luxuriant growth of large trees. There is no coal-trade of any amount at present in this region.

III.—*The Kanawha Coal-Region.*

This is probably the most important portion of the coal-field of West Virginia. Some brief descriptions of its topography, its rivers, mountains, and valleys, seem to be necessary in order properly to understand its geology. For these we are indebted to Dr. Hildreth, a good geologist of Marietta, Ohio, who explored all this country many years ago.

The Kanawha is on many accounts one of the most interesting tributaries of the Ohio. Its headmost branches rise in North Carolina, it crosses three degrees of latitude, and traverses in its windings a distance of not less than 300 miles, passing across numerous mountain-ranges, and rushing through all the rocky barriers that oppose its progress, its numerous tributaries rising in the most mountainous portions of West Virginia. Its floods are sudden and rapid, and when at full banks it pours out a volume of water that vies in strength and grandeur with the Ohio itself.

For 70 miles above its mouth its average width is about 300

yards, and with the improvements made in its channel it admits of steamboat navigation to that distance. Above its junction with the Gauley, 100 miles from its mouth, it takes the name of the New River. From this point to the mouth of the Greenbrier River, a distance of about 70 miles through Fayette, Raleigh, and Greenbrier Counties, is a continual succession of falls and rapids, making in all a descent of more than 700 feet. This portion of its course is called the Cliffs of New River. There is here really no valley or flat land along the shores, the river running in a deep cañon with steep and in many parts precipitous banks from 800 to 1,200 feet high. The New River empties into the Kanawha proper, two miles above the Great Falls, which are just below the mouth of the Gauley, the principal fall being 22 feet in height. West of this extends the fine valley of the Kanawha, in which is Charleston, the State capital, and here is the Kanawha coal-region.

The principal tributaries of the Kanawha River in going westward are Coal River on the south side, and on the north side Pocotalico, Elk, Gauley, and Greenbrier. The latter three are large and powerful streams, full of rapids, and affording an unlimited number of fine mill-seats. The Elk empties into the Kanawha at Charleston, and the Gauley just above the Falls of the Kanawha.

Although the appearance on the map, of the Kanawha and its main branch the New River, gives us the idea of a valley or thorough cut across the Great Eastern or Alleghany coal-field, and it is sometimes so described, yet this account of the great amount of fall in both the Kanawha and New River shows that this stream is merely a great mountain cataract tumbling down over the successive strata of the coal-formations, and differing only from the other rivers running into the Ohio, in the fact that its head waters rise at the highest point in the great Cumberland or Kittatinny Valley, where the surface is high enough to throw its stream over the eastern margin of the great coal-basin. In other words, instead of the eastern rim of the basin being materially cut down, the valley outside of it is simply filled up at this point, which is not very much less elevated above the ocean than many other points on the Alleghany or Cumberland Mountain.

In strong contrast to the slight elevation of the country of 200 or 300 feet at most on the Ohio side of the river, the country on the Kanawha River near its mouth has hills about 200 feet in height, for 50 miles the face of the country being broken into hills and ridges of this sort to the mouth of the Elk. From that point to the upper extremity of the salines, a distance of 15 miles, or 71 miles from the mouth, they rise to 500 feet above the bed of the river, and a few miles back in the dividing ridges they are from 100 to 150 feet higher. From this point to the falls, a distance of 25 miles, the hills have attained an altitude of from 600 to 750 feet; and above the junction of the Gauley, 100 miles from the mouth, they rise into mountain-ranges pursuing a southwest and northeast direction at an elevation of 1,200 feet. At Marshall's Pillar in the cliffs of New River, they attain a height of 1,500 feet, and are called the Gauley Mountains. Beyond this point to the valley of the Greenbrier River the country is a mountainous table-land, composed of successive ranges lying in parallel ridges, running in a northeast and southwest direction. The more elevated of these are the Sewall and Meadow Mountains.

The valley cut in the rock-strata through which the lower part of the river passes will average a mile in width, and from 200 to 700 feet deep. The corresponding rocks and beds of coal in the hills on each side of the valley afford incontestable proof that they were once united, and formed continuous beds. At 70 miles above the mouth this valley becomes much narrower, with a proportional diminution in the width of the alluvial deposits.

What are now known as the Barren Measures are thus described by Dr. Hildreth: "Below the mouth of the Elk, the hills are composed of sandstone with extensive deposits of red marly clay, which has given an argillaceous character to the soil of this region not seen in the hills above, embracing a tract from the mouth of the Guyandotte, extending northeastwardly to the mouth of the Coal River, and thence to the waters of the Little Kanawha, and over to the northern and western side of the valley of the Monongahela. Through all this region the soil is in many places deeply tinged with brown or red, probably from the oxide of iron contained in the clay, marls, or red

shale. From the mouth of the Elk to the mouth of the Gauley the country on both sides of the river, with the exception of the narrow alluvions on the water, is too mountainous and broken to admit of tillage, but will ultimately afford grazing-farms." At the date of Dr. Hildreth's article the geological surveys of Virginia and Pennsylvania were not begun, but the facts he gives are none the less valuable, and, with the aid of the light which has since been thrown upon the geology of the region, we are enabled to some extent to fix the geological level of the various localities, of which he gives us sections and descriptions.

On the Kanawha River below the mouth of the Elk, limestone is occasionally seen with sandstone, containing a proportion of mica and numerous impressions of fossil plants. Coal-deposits are less abundant in this tract of country, there being only one or two beds of any considerable thickness. The general dip of the rock-strata is toward the Ohio River, sinking those found in the lower parts of the hills above Elk, beneath the bed of the river.

Structure.—From the mouth of the Elk River upward to the Falls of Kanawha, a distance of about 40 miles, the rock-strata are composed of sand and clay, and for the first nine miles, to the centre of the salt-wells region, the rock-strata rise at the rate of 50 feet to the mile. Above this point to the upper extremity of the salines, the strata dip to the southeast, at an angle somewhat less, or about 33 feet to the mile for the distance of six or eight miles; above which point they gradually rise to the Gauley Mountain. The anticlinal line at the great salt-deposit being near the centre of the works, and the bearing of the strata being east and west, and the dip from the line northwest and southeast, at an angle of three or four degrees, this arrangement of the strata is of incalculable benefit, as it brings the salt deposits, as well as one or two additional beds of coal, to the surface, without which the expense of manufacturing salt would be greatly enhanced.

In the Kanawha region is found an important standard bed or stratum, whose persistence over wide areas and its striking peculiarity of character render it a convenient landmark, and may be regarded as clearly defining the boundary between the upper and lower coal-series. It consists of a band of black or bluish-

black silicious rock, approaching the character of a flint or hornstone, which is found in the hills at the height of several hundred feet above the river, near the falls, and after accompanying the subjacent strata in their various undulations, and their ultimate steady western dip, as they extend down the river, is seen to disappear below the water-level at the Elk River Shoals.

This black flint, or hornstone, is in some places as much as six feet thick. It is found up the Gauley River, forming the tops of the hills. Thence it has a gentle dip to the northwest, and is found up all the creeks flowing into the Kanawha, and is readily distinguished from all the associate strata. Of course it disappears under the Barren Measures in the northwestern part of the State.

Coal-Seams.—For a distance of nearly 30 miles, from a point a few miles below the falls of Kanawha, to Charleston, the coal-seams below the black flint are seen exposed in the hills. This could not have existed but for the fortunate occurrence of two broad undulations or axes returning the strata above the river, where, by a continuation of the original northwest dip, as displayed in the neighborhood of the falls, they would have been carried entirely out of view within one-third of the distance along which they are now exposed. The conglomerate disappears below the river, about three miles below the falls, and at five miles coal-seams make their appearance.

Four beds of coal are here found above water-level. The first, 60 feet above the Kanawha, is six feet thick, which is the largest, and affords the best coal. Forty-five feet higher is a thin bed of a foot and a half of coal, resting on the great bed of 40 feet of bituminous shale and clay. Two hundred feet higher is a four-foot bed of good coal, generally worked by the salt-manufacturers; and 150 feet higher is the fourth and last bed, or the third workable bed, which is four feet thick.

Above this coal, and 266 feet above the Kanawha River, occurs the very peculiar, nearly black, silicious slate, mentioned above. It is extremely hard, not being impressed by the best-tempered steel, and the Indians manufactured it into arrow-heads. It is six feet thick, in thin beds of six to eight inches. Prof. Rogers adopts it as a very important geological horizon or mark of the top of the lower coal-measures. Dr. Hildreth has

traced it from the mouth of the Elk into the Gauley Mountain, a distance of 40 miles, and eastward from the head-waters of the Elk over to the Guyandotte, a still greater distance, covering an area of at least 2,000 square miles, all of which must be underlaid by the lower coal-measures. While coals, sandstones, limestones, and shales change or resemble each other, this has a character of its own not to be mistaken. It is found every where, often high in the hills, near their tops, and appears never to fail where the geological formations are high enough.

The following section of Rogers, taken at Vineyard Hill, in the ascending order, will illustrate the lower coal-measures in this part of the State, affording a strong contrast to the meagre show of coal of the same series, as before given, in the northern part of this State. Other seams of coal probably exist in these heavy sandstone beds:

1. From the bed of the river to the first coal-seam	54
2. *Bituminous coal* (B) 5 to 6½ feet. On the river it yields 6 feet of coal, including a band of shale. Up the river, from George's and Campbell's Creeks, the shale increases until it separates it into two seams of coal	6
3. Slaty shale, bluish-drab color	40
4. *Bituminous coal* (C); thin	1½
5. Sandstone	200
6. *Bituminous coal* (D); used by salt-makers	3½
7. Silicious sandstone	215
8. *Bituminous coal* (E)	4
9. Black flint, before described	7
10. Sandstone, yellow and coarse	140
11. Reddish and yellow shales of the Barren Measures	10

This may be regarded, says Prof. Rogers, as the commencement of the series of shales, shaly sandstones, and thin calcareous bands, which overspread nearly the whole tract lying between Charleston and the Ohio at the mouth of the Kanawha, presenting for the greater part of that distance a nearly uninterrupted but very gentle dip to the northwest, then becoming horizontal, and, finally, near the Ohio, rising with a counter-dip, and forming the middle portion of this great coal-basin. These strata are higher geologically than the flint-rock, and containing two or more coal-seams where penetrated by the Ohio, constitute in this region what has been previously described as the Barren Measures and the upper coal-series.

This simple explanation of the structure of this coal-field,

and the wide extent of the region along the Ohio River covered by the deposits of the Barren Measures and upper coal-measures, which, from the thickness previously assigned to them, and the limited extent of the latter or higher strata, accounts for the small amount of coal which appears on the surface in the western or northwestern section of the State. Its treasures of fuel are deeply buried, awaiting the proper season for their development. As before noticed, the Pittsburg seam diminishes, in size, toward this southern extremity of the area in which it is found, to little more than three feet.

All those who have examined the Kanawha region concur in their accounts of the liberal supply of coal, both in respect to the number and size of the seams. Daddow, in "Coal, Iron, and Oil," enumerates eleven seams, from 2½ to 6 feet thick, actually developed between Coal River and the Kanawha, besides three others which have not been opened. There is no doubt of the great abundance of coal in this Charleston district.

Rogers's reports contain further details relating to various localities along the Kanawha, especially between the falls and Charleston, a distance of about 30 miles, and in the more lofty ridges back from the river, and along its branches, Smithers's, Ryder's, Hughes, Keller's, George's, and Campbell's Creeks. Some of the seams of coal are described as six and seven feet in thickness, and others from three and a half to four and five feet thick, some of them producing cannel and others the ordinary bituminous coals, the character of which is shown in the tables of analysis.

What has been said will convey a good general idea of this fine coal-region. After the completion of the Chesapeake & Ohio Railroad, certain portions of it will be developed by more extensive mining; but, in the present state of the country, the details here given are regarded as sufficient. Nothing imparts so much interest to a coal-region as a large production.

Within a few months (1872) the Chesapeake & Ohio Railroad has been opened from Huntingdon, on the Ohio River, at the mouth of the River Guyandotte, and near the common corner of Ohio, Kentucky, and West Virginia, by way of Charleston, to Kanawha Falls, 35 miles above that place, and about 90 miles from Huntingdon. Before these pages are through the

press, this line will be finished to White Sulphur Springs, the end of the Virginia Central Railroad, 227 miles long, thence to Richmond. This Kanawha coal-region will then be accessible, a new era will begin for West Virginia, and the country will probably improve rapidly. At present Charleston, although it is the State capital, contains but about 3,000 inhabitants. The salt-business is confined to four establishments, where 24 years ago there were forty-four. The principal production of coal at present are the following: At Peytona, on Coal River, and about 18 miles in a direct line south from Charleston, cannel-coal, of an excellent quality, for grates and for gas, is produced from seam C. The Cannelton mines, 28 miles west of Charleston, are the only other shippers of cannel-coal. There are also three shippers of bituminous coal, the Coalburg mines, on the Kanawha, 17 miles above Charleston, the Campbell Creek mines, near the Kanawha, and about four miles above Charleston, and the Raymond City mines, on the Kanawha, 19 miles below Charleston. The quantities are small, and it is shipped hitherto by barges down the river. Coal will soon be shipped by railroad to the Ohio River market.[1]

There appears to be no doubt of the existence of splint-coal in the Kanawha region which can be used as a blast furnace-fuel. Its quality for this purpose was thoroughly tested in the furnace of Mendenhall & Co., in 1867, near Wheeling, with the most satisfactory results, those parties regarding it as better adapted to smelting iron than any known coal of the Alleghany field. The coals used were from Campbell's Creek, four miles, and Coalsburg, 17 miles above Charleston, with about equal results. It is said that it is quite equal to the coal of the Mahoning Valley, in Ohio. If after further trials on the large scale this should be verified, the coals being so largely developed with every natural advantage for cheap mining, a very large production of coal for iron-making purposes may be anticipated in this portion of West Virginia.

A geological report made by Thomas S. Ridgway for the Chesapeake & Ohio Railroad Company, in 1872, contains some recent information in regard to the Kanawha coal-region. He describes the bold exposures of ponderous sandstones overlying

[1] Cor. *U. S. Railroad & Mining Register*, July, 1872.

the black flint in the hills along the Kanawha as identical with the Mahoning sandstone of Pennsylvania. Underneath are five or more coal-beds, the equivalent of those of Pennsylvania, but generally of larger size. The Big Sewall Mountain, on the east side of Fayette County, which towers 2,800 feet above the sea, and 1,500 feet above the New River, forms the southeastern edge of the Alleghany coal-basin. About ten miles down the river from this point an aggregate thickness of 26½ feet of coal has been found in five workable beds. The first seam opened being the second in the series, about 200 feet above the river, is from six to seven feet in thickness. It is a rich coking-coal, the coke having a close grain and metallic lustre. Above it is another seam, about 4½ feet in thickness, of excellent coal of the splint character, with a cleavage into large blocks. This coal, like some of the seams and parts of seams found lower down the river, is of so compact a nature that it can be used in an iron blast-furnace in its raw state. The seam next above it is of common bituminous coal, four feet in thickness. That next above, again, is 4½ feet in thickness, and exceedingly rich in lustre. Other seams of ordinary bituminous coal follow in the same ascending series. These coal-beds, with their associated sandstones and limestones, have a general inclination to the northwest of about 2½ degrees, and continue down the river with a series of undulations, appearing in the cliffs upon both sides of the river until Armstrong Creek is reached, below the mouth of the Gauley. At Cannelton, in Fayette County, 32 miles above Charleston, immediately below this point, there are five workable seams of coal opened, containing an aggregate thickness of 29 feet. The first above water-level is known as the "Smither's Creek" seam of four feet nine inches in thickness, consisting of two benches of coal separated by four inches of slate. Next above is the gas-coal, a seam of six feet eight inches, made up of three benches having clay partings. Next above is a bed of coal five feet in thickness, of a semi-bituminous quality. Next above this is the celebrated "Stockton" seam of coal, five feet four inches in thickness, averaging 3½ feet of cannel and one foot ten inches of splint coal. Next above is a seam of splint-coal eight feet in thickness, six feet of which is a solid mass, and an excellent coal for smelting purposes.

These seams continue down the Kanawha River in a series of gentle undulations. At Coalburg he saw a bed of coal seven feet thick, six of which are being mined, and which is used, in a raw state, in blast-furnaces at Cincinnati. Lower down the river he found the seam known as Campbell's Creek coal, six feet in thickness, and of a quality resembling the Coalburg coal.

The top seam of the lower coal-measures dipping westward disappears beneath the Kanawha at its confluence with the Elk River at Charleston, but some of the coal-seams appear up the valleys formed by the Elk and Coal Rivers. All the territory drained by the Kanawha and its tributaries between the Falls of Kanawha and this point contains the seams of coal above water-level, or within workable reach by shafts of no great depth.

The distances by the river from the mouth of the Kanawha to various points mentioned are as follows: To the mouth of Pocotalico 38 miles; mouth of Coal River 44 miles; Charleston, 56; Browntown, the head of steamboat navigation at low water, 68 miles; and to Cannelton, at ordinary high water, 88 miles. Coal River, by means of locks and dams, has steam navigation 25 miles above its mouth to Peytona, where there are about 50,000 tons of excellent cannel-coal shipped annually. Railroad distances are easily obtained by reference to *Appletons' Railway Guide.*

The Gauley River, a branch of the Kanawha on its north side and west of the Greenbrier, about 100 miles in length, and at its mouth more than 100 yards wide. It takes its rise in the spurs and sides of the Laurel, Greenbrier, and Gauley ranges of mountains, and the country through which it passes is mountainous and broken into lofty precipitous hills of sandstone-rock. The cliffs of Gauley are second only in height and grandeur to those of the New River, extending for many miles on each side of the stream, at an elevation of five or six hundred feet. The river itself is precipitated over falls and rapids for a considerable part of its course, and its bed is filled with huge blocks of sandstone. Toward the head these mountain ranges spread out into table-lands, here known by the name of "Glades." They lie in long narrow patches at an elevation of 700 or 800 feet above the water-courses, with an elevated ridge or border along their sides, through which at

intervals are found gaps for the water to pass off down immense precipices to the streams below. Near the head waters of the southeasterly branches extensive deposits of limestone-rock take the place of the sandstone, and continue over to the head waters of the Greenbrier. Coal of the lower coal-measures is very abundant for 60 or 70 miles above its mouth, and is found at great elevations in the mountains.

Southeastern District of West Virginia.

There is a lofty mountainous region lying above the falls of the Kanawha, and extending into the counties of Greenbrier, Pocahontas, and Randolph. For some distance within the margin of this great coal-field in the western portions of Pocahontas and Greenbrier Counties, the conglomerate base of the coal-measures overspreads a wide area, and includes along with the usual beds of conglomerate numerous beds of slate and sandstone, together with seams of coal of sufficient magnitude and purity to be worthy of exploration. The coarse and partially conglomeritic sandstone composing the celebrated cliffs of New River, forming lofty mural precipices along that stream, are of this formation, and it extends with a northwesterly dip so as to constitute the wide sheet of nearly level strata over which the Kanawha is precipitated at the falls. The series of sandstones, slates, and coal-seams of the lower coal-measures overlying this conglomerate rock are admirably exposed along both sides of the Kanawha to some distance west of Charleston. It is supposed, however, that a part if not all of the coal-seams found in the rocks of the Big Sewall Mountain appertain to the conglomerate formation or lower group of rocks. As we go southward, coal-seams are found in lower geological positions than they are in Pennsylvania.

The four counties along the southeastern line of West Virginia, Pocahontas, Greenbrier, Monroe, and Mercer, do not present a regular boundary composed at top of the conglomerate, but are intersected by deep and long valleys traversed by the waters of the Greenbrier and New Rivers, between which arise lofty knobs and broad ridges crowned by the conglomerate at the highest points.

As we trace these ridges to the south they coalesce to form

the Great Flat-top Mountain south of the New River. The Little Sewall Mountain, Meadow Mountain, and Keeny's Knobs are composed for the greater part of their height of the shales and sandstones of the lower rocks, and capped, as already mentioned, by the conglomerate. All these rocks, with some undulations, display a prevailing gentle dip to the northwest, and underlie the strata of the Big Sewall Mountain, which consist of a remarkable expansion of the strata of the conglomerate, embracing numerous strata of slates, shales, sandstones, and containing several important coal-seams.

The Guyandotte and Sandy Rivers empty into the Ohio, south or west of the Kanawha, the Sandy being the line between West Virginia and Kentucky. The space occupied by the tributary branches of these two streams covers an area of 120 miles east and west, and 100 miles north and south. Their extreme branches descend from the most elevated peaks of the Cumberland group of mountains and from the flat mountains or table-lands found between the heads of the Holston and Guyandotte. In their descent from this elevated region they pass through some of the most wild, broken, and picturesque country to be found in the West. Immense deposits of sandstone-rocks, piled up in enormous masses to the height of 1,500 or 2,000 feet, compose all the central part of this region, and but little is known as to their geological character. The streams are confined to narrow ravines and valleys so deep as hardly to admit the rays of the sun at noonday. Except near the borders of the larger streams, this whole district is a perfect wilderness. The hills and mountains, although steep and broken, are covered, like nearly all West Virginia, by an immense growth of noble forest-trees. The description hereafter given of the coal-seams found in Lawrence, Johnson, and Floyd Counties, in Kentucky, situated on the east line of that State, and on the west side of the Sandy River, will throw some light on this, the adjoining region in West Virginia. The description of the northern part of the Tennessee coal-field, by Prof. Safford, will also apply to the southern part of West Virginia.

Conclusion.—A large portion of this great West Virginia coal-region belongs to that class of localities, which is so frequently met with in America, which is said to be great in

possibilities. There are only two counties in the State which contained, in 1870, more than 20,000 inhabitants. Kanawha County, including Charleston, the present State capital, and the important salines and coal-region before described, has 22,349; and Ohio County, including the city of Wheeling, has 28,831. The next largest is Wood, including Parkersburg, 19,010, and next Mason, including Point Pleasant and the mouth of the Kanawha, with 15,978. Marshall has 14,941, and Jackson 10,300, making five of the more populous counties, and all situated on the Ohio River.

On the line of the Baltimore & Ohio Railroad the following is the population of the largest counties: Going westward, Jefferson, 13,219, and Berkeley, 14,900, both in the Valley of Virginia. Farther west, on the Monongahela River and its branches, where there is some production of coal, we have Preston, with 14,555; Monongahela, 13,547; Marion, 12,107; Harrison, 16,714; and Lewis, 10,175: and in the region of the springs, Greenbrier has 11,417 and Monroe 11,124, making in all 15 counties only in the State containing each exceeding 10,000 inhabitants. There are 22 counties containing between 5,000 and 10,000, and 16 counties with less than 5,000 inhabitants each; and the population of the whole State, in 1870, was 442,014, being about the same as Minnesota and Arkansas, and making it the twenty-seventh in population of the 37 States.[1]

The coal-regions of West Virginia are so rich and extensive that they afford a tempting subject for conjecture as to the future greatness of this State. The reader will be permitted to indulge in these for himself, and, to aid him in forming a just estimate of the value of this coal-field, he is referred to the chapter of this work as to the requisites of a successful coal-trade. One remark, specially applicable to West Virginia, may here be allowed, namely, that, although in many localities her coal-seams are now accessible, yet, like the southwestern corner of Pennsylvania and part of Ohio, she has vast fields, very deeply buried beneath the Upper Barren Measures, the upper coal-measures, and the Lower Barren Measures. The difficulties in the way of procuring from the earth portions of

[1] By the census of 1870, the production of coal in this State was 608,878 tons in that year.

its valuable mineral fuel is a most wise and provident arrangement, when we consider the wasteful propensity of mankind both savage and civilized. As that which is most easily obtained is exhausted, each successive generation overcomes increasing difficulties, discovers and obtains treasures hidden from, or out of the reach of, its predecessors. Thus every generation has a valuable legacy, not intrusted to any unfaithful guardian, but deeply stored away in its proper repository to be obtained by the legatee in person, and those minerals for which there is most demand, such as iron and coal, are found in greatest abundance.

W. B. ROGERS'S ANALYSES OF COALS OF WEST VIRGINIA.

MINE.	PLACE AND SEAM.	Region.	Carbon.	Volatile matter.	Ash.
Hansford's	Keller's Creek, Lower Seam	Kanawha Valley.	60.92	37.08	2.00
Stockton	" 2d "	"	74.55	21.13	4.32
Ruffner	Campbell's Creek, or 2d seam	"	55.76	32.44	11.80
Noyes, Rand & Co.	" " "	"	64.16	32.24	3.60
"	" " "	"	65.64	31.28	3.08
Cox & Hannahs	" " 3d seam	"	51.41	42.55	6.04
Fauris	Upper Seam, below black-flint	"	53.20	35.04	11.76
D. Ruffner	" "	"	49.84	44.28	5.88
Beamis	Third Seam	"	57.76	33.68	8.56
Smithers		"	54.52	29.76	15.76
Hughes		"	62.32	32.88	4.80
D. Ruffner	Upper Seam	"	57.28	35.08	7.64
Worth & English		"	54.00	39.76	6.24
Judge Summers	Coal Creek	"	55.55	41.85	2.60
"	Grand Creek		52.75	43.20	4.05
Wolf Creek	Big Sandy		47.15	48.00	4.85
John Lewis	Big Coal River		50.20	47.10	2.70
Cartrell's	Three-mile Creek	Kanawha County.	45,95	50.30	3.75
Friend, Welsh & Co.	Elk River	"	55.90	38.90	5.20
Lawson	Logan Court-House		58.35	39.50	2.15
Three Fork	Guyandotte		56.50	42.00	1.50
Pigeon-Creek	Big Sandy		55.00	41.90	4.00

PRESTON AND MONONGAHELA BASINS—LOWER COAL SERIES.

MINE.	PLACE.	Region.	Carbon.	Volatile matter.	Ash.
Fairfax's	Kingwood Basin, upper seam		53.77	31.75	14.48
"	" " middle seam		65.32	27.77	6.91
Forman's	S. E. of Kingwood Basin		73.68	21.00	5.32
Martin's	Deep Hollow Creek	Preston County.	65.42	23.42	11.16
Beaty	Buffalo Lick Creek		62.56	29.60	7.84
Forman's	Big Sandy	"	67.60	22.40	10.00
Morton's	Brandonville		65.28	30.80	3.92
Price's	New Kingwood	Cheat River.	60.32	25.00	14.64
Seafort's	Big Sandy River		66.64	27.12	6.24
Hagar's	Kingwood Basin		68.32	26.48	5.20
"	" "		67.28	29.68	3.04
Wall's	Big Sandy		60.04	26.88	13.08
Cresapp's	Kingwood		64.26	30.26	5.32

UPPER COAL SERIES.

Clarksburg	Main Seam		56.74	41.66	1.60
"	Cannel		49.21	45.43	5.36
Pruntytown	Main Seam		57.60	39.00	3.40
Morgantown			60.54	37.30	2.14

Virginia.—The West Virginia coal-field has been described as embracing the whole of that portion of the Alleghany coal-deposit which formerly belonged to the old State of Virginia, before the formation of the State of West Virginia. So small a portion of the coal-field remains in the State of Virginia proper as to be scarcely worthy of a separate description. It consists principally of the counties of Buchanan, Wise, and Lee, in the southwestern angle of the State, forming the eastern declivity of the Cumberland Mountain adjoining the Kentucky line. In Tazewell and Russell Counties, immediately east of the district mentioned, are found long lines of dislocation by which this southwestern part of the State is wonderfully marked, pressing up to the very margin of the coal-rocks strata far lower in the series, and even crushing these rocks and their contained seams of coal, folding them together, and turning them over into inverted dips. *See* the section of the valley of Tennessee, page 354). Also for a good geological report see *U. S. R. R. & Mining Register* for Sept. and Oct., 1872.

Among the changes exhibited in the formations where traced from a northeastern to a southwestern direction may be noticed an increased coarseness of the material and greater thickness, and a flattening of the dip, and at the same time the small seams of coal which sometimes occur in the formations below the conglomerate also increase in size and value, until in Tennessee and Eastern Kentucky they are of great importance.

Lesley, in his "Manual of Coal and its Topography," describes the false coal-measures, or sub-conglomerate coal which occurs on New River, in Montgomery County, Virginia, being on the eastern margin of the coal-field. Here the two lower beds attain their greatest thickness, the lower one being from two to 3½ feet thick, and the second one, which is from 20 to 60 feet higher, is from six to nine feet thick, seldom yielding more than four feet of coal. Along the eastern foot of the Brush Mountain, back of Christianburg and Blacktown, both these seams are workable for 30 miles, yielding a good and tolerably firm coal. South of the New River, however, through Wythe County for 100 miles, these coal-beds are thin, faulty, and crushed.[1] It

[1] *See* Lesley's "Manual," pp. 67–69, and 148. Daddow, who visited the region, describes it, "Coal, Iron, and Oil," pp. 407–410.

will be hereafter noticed that these sub-conglomerate coals are largely developed on the west side of this great coal-field in Eastern Kentucky, directly west of the region in Montgomery County, Virginia, above described, and in Tennessee.

In another publication, Mr. Lesley thus describes these coals: "Underneath the true coal-measures of Pennsylvania, Ohio, and Northwestern Virginia, and underneath the millstone grit conglomerate, at its base, and under the red shale XI., which underlies the last, there begins, even in Pennsylvania, to appear an older coal-formation, connected with the Upper Devonian white mountain-sandstone, No. X. It is seen in one or two beds two feet thick at the head waters of the Juniata, and at Tipton Creek, where are two coal-seams three feet thick, 600 feet below the great conglomerate. It is mined where the Monongahela waters cut through Chestnut Ridge from Virginia into Western Pennsylvania. It has been mined in the mountains on the Potomac, below Cumberland. It appears occasionally in Northern Middle Virginia, on the western side of the great valley of Winchester. It increases in importance along the western outcrop of the great coal-field through Eastern Kentucky, until it enters Tennessee.

"It seems, however, to obtain its maximum development in Montgomery County, on the New River, in Southern Virginia. Here it is seen to consist of two principal coal-beds and several minor seams. The lowest bed reaches the thickness of four feet, and the next one above it is, in some places, nine feet thick. Near the New River these two beds are seen to be covered by at least 1,000 feet of red shale, upon which rests a subcarboniferous limestone. Between Christianburg and Blacktown, north of the New River, a regular synclinal coal-basin has been preserved, in a crushed condition, for a few miles, upon the eastern side of the great fault which crosses the river in front of the gap.

"But there is still another series between these false coal-measures and the true coal-measures. At the top of the red-shale formation XI., Rogers's Umbral, lie alternations of carboniferous, argillaceous, and silicious shales, containing at least one real coal-bed."

Anthracite coal has also been found in Pulaski, Montgom-

ery, and Wythe Counties, Virginia, along the New River. This region is remarkable for faults of great size, which occur frequently in Southwestern Virginia. Although the corresponding region in Pennsylvania shows vast undulations and foldings of the strata, yet the regular order and arrangement of the formations are not disturbed, but they follow each other often throughout the flexures. But, in the country now under consideration, the foldings of the strata have been accompanied by long, straight lines of fracture, often 100 miles long, so that formations which were four or five miles below are brought up, and the edges of the fracture brought in contact with newer rocks of higher series, such as those containing coal-beds, and then the whole was reduced to a common level by extensive denudation. That fragments of the coal-beds should be found among these dislocated strata is to be expected. All anthracite coal is found in disturbed formations, and coal found in such localities is generally anthracite. Where the proper conditions occurred, semi-bituminous coal is found, as in Brush Mountain, along the northwestern line of Montgomery County; while in Price's Mountain, six or seven miles southeast of this, is a very pure anthracite containing 89.25 of carbon, 2.44 of water, etc., and 8.3 ashes, with a specific gravity of 1.37. There are not more than one or two beds, and they occur in a ridge about two miles wide, the strata lying in an anticlinal form, dipping on each side, and abutting against the Trenton limestone. The circumstances are not favorable for the existence of beds in good condition for working; they are liable to be greatly disturbed by faults, and the coal itself very much broken. Through Pulaski and Wythe Counties, the coal is shovelled out of some of the beds like sand. (J. T. Hodge.) With the building of railroads leading to the regular coal-formations of West Virginia, these broken and crushed deposits will probably have no more than a scientific interest. There are reports of similar bodies of anthracite coal in Berkeley and Morgan Counties, but, if they exist, they are in the vicinity of the great Cumberland (Maryland) bed, and are not probably of any present value. Some of the localities mentioned in this volume belong to the curiosities of our subject, and these may be considered among the number.

XIII.

OHIO.

NOT the least important among the resources of the great State of Ohio is found in the very fine coal-field which covers her eastern border. "Most countries," says Prof. W. W. Mather, in his report on the geology of this State,* "depend for their mineral wealth on mountainous or barren regions, but Ohio, in common with some other portions of the United States, is blessed not only with a fruitful soil, but also with inexhaustible subterranean riches. The coal-measures within the State occupy a space of about 180 miles in length, by 80 in breadth at the widest part, with an area of about 10,000 square miles, extending along the Ohio River from Trumbull County in the north, to near the mouth of the Scioto on the south. The regularity in the dip, and the moderate inclination of the strata, afford facilities to the miner not known to those of most other countries, especially Great Britain, where the strata in which the coal is embedded have been broken and thrown out of place, since its deposit, occasioning numerous slips or faults of many feet, causing much labor and expense in again recovering the bed which is to be sought either above or below. In Ohio very little difficulty of this kind occurs, faults or slips of a few inches or a few feet only being met with."

* The first geological survey of Ohio was prosecuted for two years, and the results were published in 8vo pamphlets, that of 1837 containing 134 pages, and that of 1838, 286 pages. It was then abandoned for thirty years, after being only fairly begun. A new survey was authorized in 1869, under the direction of Prof. J. S. Newberry and a corps of able assistants. In compiling this chapter, his reports of progress for 1869 and 1870 furnish the materials used, to which are added a letter from the State geologist in regard to the upper coal-measures, and a few facts from other sources.

Structure.—The most striking feature in the geology of Ohio is the remarkable anticlinal, or up-lift, at Cincinnati, which has been before referred to. As the summit of the Alleghany Mountain, in the central part of Pennsylvania, forms the eastern, so this great arching wave in the rocky strata in the central part of Ohio, forms the western boundary, of the finest coal-basin in the world. For, although there is no mountain on this its western border, yet the lower Silurian rocks have been brought up to the surface. The highest portions of this great arch in the strata were afterward removed, exposing to view the lowest visible rocks in Ohio, the blue limestone of Cincinnati, the equivalent of the Trenton and Hudson River groups. This anticlinal extends northward, forming islands in the western part of Lake Erie, and southward across the State of Kentucky. The older formations below the coal, as these now appear on the surface in Ohio, count off in the same order from the anticlinal line, both westward and eastward. In the latter direction, or toward the coal-field, we find them in the usual order, but with some important intervals or omissions up to the Carboniferous or coal-bearing rocks. Our old friends the Ponent, Umbral, and Vespertine, and the Catskill group, the great, double, red-sandstone mountain with its red-shale valley of Eastern Pennsylvania, have disappeared, without leaving a vestige to mark their places in the formations. Even in the western counties of Pennsylvania, the formations from the Chemung rocks upward had become so mingled as to be distinguished with difficulty. In the Ohio Valley a quiet sea prevailed, and limestones were formed, while farther east were moving oceans of sand, mud, and pebbles.

The bed of the Ohio River at Cincinnati is 432 feet above tide-water, 133 feet below the level of Lake Erie, and it is both physically and geologically the most depressed portion of Ohio.

The general dip of all the Ohio rocks, east of the great Cincinnati anticlinal, is toward the east, and each of the formations disappears in its turn in going eastward under the succeeding one, and all the others under the Carboniferous. Their order and maximum thickness are as follows: (1) Cincinnati, 1,000 feet; (2) Clinton, 10 to 60; (3) Niagara, 275; (4) Water-Lime and Salina, 0-150; (5) Oriskany, 100; (6) Corniferous, 100; (7) Ham-

ilton, 20; (8) Huron Shale or Portage, 350; (9) Erie or Chemung, 400; (10) the Waverly sandstone, the lowest member of the Carboniferous formation. Its fossils prove it not to be a portion of the Chemung and Portage, as was formerly supposed. The latter are represented by the Erie and Huron shales in Ohio. In the southern part of the State the Waverly group is 640 feet thick. (11) Next occur the Carboniferous limestone and (12) conglomerate, the latter being about 100 feet, and only occurring in patches; (13) The Coal-measures which thicken toward the east, and each of the coal-seams and accompanying strata, also pass under the succeeding one in that direction. The geology of Ohio is therefore very simple so far as its structure is concerned, her rocks being all stratified, and very little broken or disturbed, as compared with those of Eastern Pennsylvania and other regions, and fewer strata appear on the surface. The general visible dip is about 9½ degrees south of east, at the rate of a little less than 100 feet in three miles, and the coal-measures, forming the highest member of the series, growing thicker in that direction. But, from the recent survey, it appears that there is not a general uniform dip in the strata of the coal-measures toward the east or southeast, but that there occurs a system of flexures in the coal-strata, having a close connection with the present topography of the country, and the general direction of the water-courses. Thus the eastern dip is frequently counteracted by folds which elevate and depress the strata from their normal planes. It is not improbable that these are a continuation of the flexures which are observed on so large a scale in the eastern part of the same coal-field in Western Pennsylvania.

In the vicinity of Wheeling, near the centre of the great Alleghany coal-basin, of which this coal-area of Ohio forms a part, the coal-measures have a thickness of about 1,500 feet, and include perhaps ten or twelve workable seams of coal. In this eastern and southeastern part of the field not only are the lower coal-measures fully represented, but also the superincumbent barren measures, and the upper coal-measures, including the Pittsburg seam, this being geologically the highest portion of the Ohio coal-region.

Boundaries of the Coal-field.—Looking for a moment at

the outer or western rim of the coal-field of Ohio, we will observe that the series of rock-strata composing the coal-formations terminate on the outer margin of the basin in heavy masses and abrupt precipices, as in the vicinity of Lancaster, in Fairfield County, and several other places near the borders of the great limestone formations, which occupy the middle and western portions of Ohio, and they are indented like the bays and headlands of a modern sea-coast, as though they composed the borders of the ocean which then covered the larger portion of the valley of the Mississippi. The coal-basin is bounded on the west by a continuous but crooked line from the Ohio River, in Scioto County, to the Pennsylvania line near Sharon, within a line running from that place to Ravenna, Akron, Wooster, Dover, Brownsville, Logan, and Hanging Rock. Or, to follow the line of outcrop, more particularly we have in the north, in Trumbull County, the boundary of the coal-field from where the Pymatuning Creek crosses the State line, curving southward, and the other side of the curve being on Mahoning Creek at Youngstown. Thence the line is westward nearly along the north line of Mahoning County, from the northwest corner of which it puts out a long, slender cape through Portage into Geauga County, its west boundary being near the Cuyahoga River, until it enters Summit County. From Ravenna the line is nearly southwest, to the north line of Holmes County, except a well-defined cape running into the southeast corner of Medina County. Thence southward it follows near the east line of Holmes and Knox Counties, and includes the southeast corner of Licking County. It then passes near the line between Fairfield and Perry Counties, with a deep indentation at the Hocking River Valley, extending to the west line of Athens County; thence westward and southwest to include the southeast part of Hocking County, three-fourths of Vinton, nearly all of Jackson, and the eastern part of Scioto County. The counties wholly covered with coal are Mahoning, Columbiana, Stark, Holmes, Tuscarawas, Carroll, Jefferson, Harrison, Belmont, Guernsey, Coshocton, Muskingum, Perry, Noble, Morgan, Monroe, Washington, Athens, Meigs, Gallia, Lawrence, and nearly all of Jackson.

And the counties of which the eastern or southeastern parts

only are covered with coal are Trumbull, Portage, Summit, Medina, Wayne, Licking, Fairfield, Hocking, Vinton, and Scioto. There are also some outliers or small detached basins in Wayne, Ashland, Richland, and Knox Counties. The boundary on the east is the State line, the same field extending eastward over all Western Pennsylvania.

Topography.—The rim or outcrop line of the coal-basin of Ohio is as nearly level as might be expected in a country where the summits of the hills lie in nearly a horizontal plane, the variations from such a plane seldom exceeding 100 feet, and being from 350 to 450 feet above the level of Lake Erie.

From Lake Erie the country rises to an elevation of 600 feet above the lake, within the coal-field. Thence south to the Ohio River, the summits of the hills are nearly a horizontal plain 600 to 650 feet above Lake Erie, which summits represent an ancient plain into which the streams operating through immense periods of time, have excavated numberless valleys and ravines. These hills are nowhere the result of upheaval, or other disturbances of the strata, as there are no such irregularities in the geological structure of Ohio. Whatever variety there is in its surface is due to the slow but powerful disintegrating force of running water. When the coal-bearing rocks were deposited, the surface of the country was a monotonous level, and they were, as they are still, nearly horizontal. Many of the coal-seams are irregular, but this is due to the method of their formation, and not to geological disturbances. (Andrews.)

The valleys of all the principal streams are deep, generally well defined, and the work of aqueous erosion has been immense. All the streams have innumerable tributaries, which have cut for themselves deep channels, the surface being completely eroded into a vast and wonderful system of ramified valleys. The hills and ridges are simply the remnants of what were once continuous rock-strata. In many sections the hills are sculptured in rounded and graceful forms, while in others the streams have cut for themselves channels with almost perpendicular sides, giving to the scenery a bold and mural character. The latter characteristics are more often seen where the streams flow over the heavy sandstone strata. Between Lancaster and Logan the Hocking River flows in a valley bordered

by high cliffs. Some of its tributaries have eroded channels so deep and narrow that they may be properly termed cañons. The Licking River has excavated a similar channel in the vicinity of Black Hand. In many places we find a cliff on one side, and rounded hills on the other, as on the Marietta & Cincinnati Railroad, near Cincinnati Furnace, in Vinton County. (Andrews.)

All the streams within the Ohio coal-basin take a southeastern direction, which is caused by the eastern and southeastern dip of the rock-strata. The whole coal-field slopes to the south and southeast, and consequently the drainage is to the Ohio River. It is, however, somewhat undulating, and often exhibits areas of considerable extent, with a northern slope and drainage. The principal river within the basin is the Muskingum, which, with its longest tributary, the Tuscarawas, drains a large portion of its area. From Dresden to Marietta, 90 miles, the Muskingum descends 130 feet, or 20 inches per mile, and Prof. Andrews notes as an interesting fact that it has its bed throughout its whole course a little above the level of Lake Erie. The Little Muskingum River flows in its entire course in a basin parallel to the Ohio River, and only eight or ten miles from it. The boundary of the upper coal-measures seems to form north of the Muskingum, the water-shed dividing the waters flowing into the Ohio from those carried off by the Tuscarawas and Muskingum.

The Ohio River flows southwesterly through the more depressed portion of the coal-measures, cutting its channel across the strata where it found the least resistance, but it does not follow the synclinal axis or bottom line of the great basin, and hence there is not a uniform display of coal-seams along the river.

There are deeply-buried channels of excavation in the valleys of the Western rivers, as first pointed out by Prof. Newberry. The Ohio throughout its entire course runs in a valley which has been cut nowhere less than 150 feet below the present bed of the river. The Tuscarawas at New Philadelphia is 175 feet above its ancient rock-bed. The Cuyahoga, Vermilion, and other streams running into Lake Erie, are more than 100 feet above the rock-bottom of their excavated troughs. At Cincin-

nati the gravel and sand extend more than 100 feet below low water, and the bottom of the trough has not been reached. These old, deeply-excavated river-channels were filled up and in many cases entirely obliterated by the inundation from the north of an ocean, as it were, of clay, sand, gravel, and bowlders, during the Drift period. These remarkable deposits, which, it is supposed, were moved by glaciers and icebergs, cover the State of Ohio as far south as the city of Dayton. Fortunately, these loose surface deposits are much thinner within the coal-basin than in the parts of the State farther west.

The Scioto, the principal stream in the middle of the State, flows just outside of the coal-bearing rocks, and the accompanying Waverly group through a level, smooth country, without the hills which characterize the coal-basin. It is evidently thrown off by the western rim of the great basin, and thus obliged to take a southward direction. Its course is serpentine, and it has a descent between Columbus and Portsmouth of 225 feet in a distance of 150 miles, or 18 inches per mile.

Within the Ohio coal-field the surface is rolling or broken, and the soil is mostly derived from the subjacent rocks. The lower coal-measures, composed of alternations of limestone, shales, sandstones, fire-clays, and beds of coal, furnish a soil that is well watered, and fertile to the hill-tops. The Barren Coal-measures, and such members of the upper series as fall within the limits of this State, consisting in the greater proportion of argillaceous shales, yield an intractable, less fruitful soil.

Varieties of Coal in Ohio.

Following an economical classification, Prof. Newberry divides the coals of Ohio into three classes: first, the dry open burning or furnace-coals; second, cementing or coking-coals; third, cannel-coals.

The first, which is popularly known as block-coal, includes those that do not coke and adhere in the furnace, and are such as may be used in the raw state for the manufacture of iron. These furnace-coals have generally a distinctly-laminated structure, and are composed of bituminous layers separated by thin partitions of a material allied to cannel, which does not

coke. Hence the bitumen in them is held in cells and cannot flow together, and give the mass a pasty, coherent character. In Ohio it chances that the lowest stratum in the series is generally a furnace-coal. Along its northern line of outcrop this is known as the "Brier Hill coal." This coal enjoys a deserved celebrity for its adaptation to the manufacture of iron, and now furnishes the fuel by which half the iron produced in the State is made. In consequence of the structure of the coal-basin this seam underlying all the others and dipping toward the south and east is, for the most part, covered by the overlying rock. As a consequence, up to the present time it has been worked only along its line of outcrop, and the great area it occupies below drainage is almost untouched. The Hocking Valley or Sunday Creek coal is supposed to have this open-burning character. It covers not less than 600 square miles, and maintains a thickness of from six to eleven feet, with a remarkable uniformity and purity of composition.

The second class of Ohio coals, embracing by far the greater portion, are of the ordinary coking, bituminous kinds, which to a greater or less degree melt and agglutinate by heat. If used for smelting iron, this property would cause them to choke up the furnace, and arrest the equal diffusion of the blast through the charge. Hence they cannot be used in the raw state for the manufacture of iron from the ore without coking. This process consists in burning off the gaseous or bituminous portion which leaves them in the condition of anthracite, except that, as this change is effected without pressure, the resulting material is cellular and spongy. Coals of this character, when free from sulphur, their great contaminating impurity, are used for the manufacture of gas; the volatile portion, driven off in the retorts, serving the purpose of illumination, while that which remains is coke, and may be used as fuel. These cementing coals are without the partitions described as belonging to the furnace or block coals, but show upon fracture broad, brilliant surfaces of pitch-like bitumen. It is black in color, its lustre resinous, it breaks into trapezoidal blocks, and during combustion agglutinates, giving a bright-yellow flame.

The third variety consists of the cannel-coals, which in England first went by the name of candle-coal, from its flame

resembling that of a candle, which in process of time became corrupted into cannel, which it still retains, although objectionable in some respects. It resembles a dark shale, highly impregnated with bitumen, and burns with a bright flame, but does not agglutinate. Where the earthy matter predominates it passes into bituminous shale, and the transition is often observed in short distances. The ordinary bituminous coal often passes into cannel, or they are found blended together. It rarely contains any traces of vegetable matter, but marine shells have occasionally been observed. (J. W. Foster, in Report, 1838). Prof. Newberry describes cannel-coals as of a more compact and homogeneous texture, and as containing a larger percentage of volatile matter than the others—also the gas they furnish has higher illuminating power. Hence they would be used, to the exclusion of all others, for the manufacture of gas, only that the coke which they furnish is of inferior quality. They are, therefore, for the most part, employed as household fuels, for which they are specially adapted, and in small portions for enriching the gas produced from coking varieties. He thinks the marked differences exhibited by those three varieties of coal are doubtless due to the circumstances of their formation. The cannel-coals were deposited in lagoons of open water in the coal-marshes where the finely-macerated vegetable tissue accumulated as carbonaceous mud. Hence they have a large percentage of hydrogen, and their gas has higher illuminating power. Hence also the shells, fishes, amphibians and crustacea, all aquatic animals, so generally found in them.

It will have been observed that all the coals of Ohio belong to the group known as bituminous coals, but these exhibit very considerable variety in their chemical and physical characters, and the different varieties are applied to very different uses. (Report of 1870.)

The chemical examinations of the Ohio coals show that the relative amount of moisture varied from 1.10 per cent. to 9.10 per cent. of the coal. As a general rule, the coals from the northern part of the State contain relatively less moisture than those from the southern portion. The amount of volatile combustible matter varied from about 28 per cent. to something over 40 per cent. of the native coal. The percentage of fixed

carbon varied from 34.10 to 65.90, the former being the amount found in the upper coal from Holmes County, and the latter in the Steubenville shaft-coal. The proportion of ash found in the bituminous coals of this State varies from 0.77 of one per cent. found in a coal in Jackson County, to 17.10 per cent. present in a coal from Holmes County. The mean average of ash found in 88 coals from the portion of the State south of the Central Ohio Railroad was 4.718, and that of 64 coals north of that line 5.120 per cent. The mean average ash of 152 coals was 4.891 per cent.; of these 10 exceeded 10 per cent.; omitting these, the average of the remainder amounts to 4.280 per cent. The ash found in 11 Ohio cannel-coals examined was 12.827 per cent. The average proportion of sulphur in Ohio coal was 1.551 per cent., that from the lower half of the State being 1.229 per cent., and that of the coal from the upper half 1.836 per cent. The sulphur is not always wholly in combination with iron, and in such instances nearly the whole of it passes off with the volatile matter, while in other instances very little escapes with the volatile products.

The Series of Coal-Strata.

The lower coal-measures contain in Ohio seven and in some places eight beds which lie below the Pittsburg seam, and which include most of the important coal-beds of the State. The examinations made by Prof. Newberry, in the course of the geological survey now in progress, have shown that instead of forming one symmetrical basin with a tolerably uniform dip toward the southeast, the coal-measures form several troughs more or less parallel with the axis of the great one of which they form a part. On the east side of each of these subordinate basins, the strata rise, thus neutralizing the generally easterly dip, so that on the line of Columbiana County, and within forty miles of Pittsburg, the section of the hills is nearly the same as that found on the border of the coal-field 100 miles west, the average dip in this interval being not more than three feet per mile. The importance of this knowledge of the structure of the coal-field will be apparent at a glance. It shows that the coal-seams of the lower coal-measures are within easy reach along all the valleys that cut this portion of the coal-basin, and

that they are not, as has been sometimes supposed, carried by a uniform easterly dip so far below the surface as to be practically inaccessible. It also shows that the number of coal-seams has been sometimes erroneously duplicated, and that those of Salinesville are the same as those in the lower portion of Yellow Creek. (Newberry.)

It appears, by Prof. Newberry's second report, that the coal-measures across Northern Ohio below the Barren Measures, correspond with those of Pennsylvania, some of the smaller seams being enlarged. There are six or seven workable beds of coal along this line, and two limestones. These limestones are the most constant elements in the section, and will be the most useful guides to any one studying locally or generally the geology of this district. Of these the lower is generally blue, often flinty, and is associated with a band of iron-ore. In Western Pennsylvania it is the "ferriferous limestone" which occurs between coal-beds B and C, and where it is overlaid by the buhrstone and iron-ore.

The second or upper limestone is always lighter in color than the first, from which it is separated by from 30 to 100 feet, and it is usually designated the gray limestone, and in Columbiana County the white limestone, from the comparative whiteness of the lime made from it. It is visible almost uninterruptedly from the banks of the Mohican to the Pennsylvania line. It is situated between coal-seams C and D, as we shall designate them, or Nos. 4 and 5 by Prof. Newberry's nomenclature; that is, coal No. 4, or C, lies between the two limestones. There is in Ohio another limestone over coal-seam No. 7, in the Barren Measures, but, though sometimes ten feet in thickness, it is not as constant as the blue or gray limestones, covers a much more limited area, and is therefore a less valuable guide. Each of these limestones has a coal-seam under it, often in immediate contact, but sometimes separated from it by a few feet of shale. In the southern and eastern portions of the Ohio coal-field, and on Yellow Creek in Jefferson County, and thence south, there are several other limestones.

The following general section, furnished by Prof. Newberry, will serve to illustrate the composition of the Coal-Measures of Ohio. The letters and Pennsylvania names in

parentheses have been added to designate the corresponding beds in that State and in Virginia:

SECTION OF THE UPPER COAL-MEASURES OF OHIO.

No.	STRATA.	Feet.	No.	STRATA.	Feet.
36	Limestone	7	9	Shale and Sandstone	50 to 100
35	Sandstone	40	8	Shale	2 " 10
34	*Coal No.* 13	1 to 3	7	*Coal No.* 7a (F.)	1 " 6
33	Sandstone and Shale	70	6	Fire-clay	1
32	*Coal No.* 12	1 " 6	5	Sandstone and Shale } Barren Measures.	50
31	Sandstone and Shale	20 " 40	4	*Coal No.* 7	0 " 5
30	*Coal No.* 11	1½ " 4	3	Fire-clay	3
29	Fire-clay	1	2	Limestone	2 " 10
28	Sandstone and Shale	50	1	Mahoning Sandstone	
27	Limestone	6		Along the Ohio River the section between Nos. 8 and 9 differs somewhat from the above, owing to intercalated beds, and is as follows:	
26	Sandstone	45			
25	*Coal No.* 10	3 " 6			
24	Fire-clay	3			
23	Sandstone	35 " 40			
22	*Coal No.* 9	2½			
21	Fire-clay	½			
20	Limestone	30 " 70	11	*Coal No.* 9	2½
19	Black Shale	2 " 10	10	Limestone	70
18	*Coal No.* 8 (H. Pittsburg)	4 " 8	9	*Coal No.* 8c	2 " 4
17	Fire-clay	3	8	Fire-clay	2
16	Limestone	4 " 30	7	Sandstone	5 " 35
15	Shale and Sandstone	110	6	*Coal No.* 8b, with Shale	1
14	Shale } Barren Measures.	5 " 10	5	Limestone	20
13	Crinoidal Limestone	2 " 3	4	*Coal No.* 8a	1½
12	Shale	1 " 17	3	Limestone	25
11	*Coal No.* 7b (G.)	½ " 4	2	Shales	5
10	Fire-clay	2	1	*Coal No.* 8	8

SECTION OF THE LOWER COAL-MEASURES OF OHIO.

No.	STRATA.	Feet.	No.	STRATA.	Feet.
29	Mahoning Sandstone	30 to 80	14	Shale and Sandstone	10 to 50
28	Gray Shale	5 " 20	13	Blue or Ferriferous Limestone	4
27	*Coal No.* 6 (E, Upper Freeport)	4 " 7	12	*Coal No.* 3 (B)	2 " 4
26	Fire-clay	3	11	Fire-clay	6 " 12
25	Limestone	0 " 3	10	Shale and Sandstone	75
24	Shale	50	9	*Coal No.* 2, generally thin	1 " 6
23	*Coal No.* 5 (D, Lower Freeport)	2 " 4 4	8	Shale	20
22	Fire-clay (locally hard clay)		7	Sandstone	20 " 70
21	Shale and Sandstone	20 " 60	6	Shale	5 " 40
20	Gray Limestone	3 " 6	5	*Coal No.* 1 (A) "Briar Hill" or "Block Coal"	4
19	*Coal No.* 4 (C. Kittanning)	2 " 6	4	Fire-clay	3
18	Fire-clay	3	3	Shale	0 " 20
17	Shale and Sandstone	20	2	Conglomerate	0 " 100
16	*Coal No* 3a, local	2 " 3	1	Waverly	
15	Fire-clay	3			

The intervals between the coals in the above section vary greatly in different parts of the coal-field: for example, between coals No. 6 and No. 7, from 50 to 100 feet; between coals No. 5 and No. 6, from 20 to 60 feet, where both are present. On the western margin of the coal-field, coal No. 5 is generally wanting, and the interval between No. 4 and No. 6 is reduced from its eastern average of 100 feet to 25 feet. Between coals

No. 4 and No. 3, the interval varies from 20 to 80 feet, coal 3a and sometimes another thin seam coming in where the limestones are most widely separated. The intervals between coals No. 3 and No. 2 is much more constant than between No. 2 and No. 1, the latter interval sometimes varying, within a few hundred yards, 50 feet, this variation being mainly due to waves in the lower seam. Where the more constant coals are most widely separated, intercalated seams often come in, and sometimes acquire considerable local importance.

The iron-ore horizons in the above section are: 1. That of the black band over No. 7; this black band is locally replaced by nodular, calcareous ore—"Mountain-ore"—or by "Kidney" iron-ore, all giving way in places to a buff limestone. 2. A band of nodular ore over No. 5, best marked toward the west. 3. Nodular or plate ore on the gray limestone. 4. Nodular or plate ore on the blue limestone, best marked and very conspicuous toward the east. 5. Over the conglomerate and under coal No. 1, best marked toward the south and west.

The relations of the coal-seams above No. 8, to those of Pennsylvania and West Virginia, have yet to be determined. No. 8 is the Pittsburg seam.

The Seams of the Lower Group of Coals, as described by Prof. Newberry.

North of the National Road we have, in Ohio, below the Barren Measures, from six to eight workable seams of coal, forming what is known as the lower coal series. An enumeration of these beds, with a few notes descriptive of the changes observed in tracing them along 100 miles of outcrop, will perhaps serve to give a clear idea of the composition and structure of the coal-measures:

Coal-seam No. 1. (A.)—This is the lowest seam of the series in Ohio, and is that best known as the Brier Hill or Mahoning Valley coal. It is now regarded as the most valuable coal-seam in the State, from the fact that in many localities it is of good thickness, of remarkable purity, and well adapted, in the raw state, to the smelting of iron-ores. It is, indeed, a typical furnace-coal, and forms the fuel by which fully half

the iron produced in the State is manufactured. Unfortunately, this is an exceedingly irregular seam, and, over a large part of the region where it is due, it is found to be wanting.

This peculiarity is owing to two causes, viz., it was the first accumulation of carbonaceous matter in the great peat-bog that subsequently became our coal-basin. As a consequence, it occupies only the lower portions of the irregular bottom of this basin, and was never deposited over the ridges and hummocks which fringed the margins, or, as islands, dotted the surface of the old coal-marsh.

The second cause of its absence is, that it is overlaid by heavy strata of sandstone which were once beds of sand, transported by currents of water in rapid motion, and these currents have, over considerable intervals, washed away the coal and left in its place sand—now sandstone—resting on the lower rocks.

I have traced the outcrop of coal No. 1, from the National Road around to the Pennsylvania line, and have evidence of its being reached by borings at several places far in the interior of the coal-basin. In the Mahoning Valley coal No. 1 has its best development. It is here very compact, working in large blocks, from which fact it has received the name of "block-coal," and is remarkably pure, as demonstrated by the following analysis:

Analysis of Coal No. 1, or Block-Coal of Ohio.	Brier Hill, Youngstown.	Upson's Mine, Summit Co.	Johnson's, Summit Co.	Franklin Co., Summit Co.	Willow Bank, Massillon.	Knox Tp., Holmes Co.
Specific Gravity	1.234	1.264	1.256	1.271	1.247	1.276
Water	3.60	5.067	2.70	3.40	6.95	5.55
Volatile, Combustible.	32.58	39.231	37.30	36.10	32.38	40.10
Fixed Carbon	62.66	53.404	58.00	58.70	57.49	51.79
Ash	1.16	2.298	2.00	1.80	3.18	2.56
Total	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	.85	.549	.92	.799	.88	1.21

As shown by its large percentage of carbon, the heating power of the Brier Hill coal is great. It is also open-burning, in virtue of its laminated structure, and is the only fuel used in the furnaces of the important iron-district of the Mahoning Valley. It is also extensively employed as a furnace-fuel in Cleveland, and is, in fact, the basis of the great iron industry of Northern Ohio.

In Geauga County the Brier Hill coal reaches as far north as Burton and Newberry, but only in a narrow strip and detached islands, and is there thin and of little or no value. In Portage County it is also generally thin or wanting, but its outcrops are concealed by heavy beds of drift, and it will probably be found of good thickness in many places where it is not now suspected to exist.

In Summit County, coal No. 1 thickens up again, locally attaining dimensions of from three to six feet. It lies, however, in a series of basins often of limited extent, but it occupies fully half the southern portion of the county in the townships of Tallmadge, Coventry, Springfield, Franklin, and Greene. It also reaches, in a narrow basin, so far into Medina County that its northwestern outcrop is within eight miles of Medina Village. In Summit this coal-seam is generally somewhat more bituminous than in the Mahoning Valley, breaks more irregularly, and has less of the block character.. These physical differences are associated with a slightly different chemical composition, as is shown by the table of analyses; but occasionally, as at Johnson's shaft, in Franklin Township, it exhibits almost precisely its prevailing character in Mahoning County. There, as farther eastward, it is generally an excellent coal, and is destined to contribute much more largely than it has yet done to the enrichment of Akron and vicinity, by furnishing an abundant supply of fuel adapted to all forms of manufacturing industry.

From Wadsworth, Medina County, the western line of outcrop of coal No. 1 pursues nearly a southern course to Fairview, in Wayne County, where it crosses the line of the Pittsburg, Fort Wayne & Chicago Railroad. At Clinton, Fulton, and Massillon it is extensively worked, and the mines in this vicinity supply a large amount of coal for the Cleveland market, as well as for iron-making, and other industries at home.

From Massillon to the Ohio River, along its line of outcrop, coal No. 1, as a general rule, is of little importance. It appears of workable thickness at frequent intervals, but is generally thin, of inferior quality, and oftener absent, or present as a mere trace.

21

At Spencer's Mill, in Holmes County, coal No. 1 is four feet in thickness, and at several other places in this vicinity is from two to three feet thick. This is also the seam worked at Mast's mine, two miles north of Napoleon, where it is three feet thick, and of excellent quality; so that it deserves to be enumerated among the elements that compose the mineral wealth of this richly-endowed county; but it is here surpassed in value by some of the overlying seams. Its line of outcrop has not been carefully examined, but it is apparently of no great value in any locality between Holmes and Jackson Counties. In Jackson, and thence southward, it regains something of its traditional character and value, and is somewhat extensively mined and used as a furnace-coal.

From these and other facts which have come to my knowledge, I feel justified in saying that the country just about New Lisbon is underlaid by an important basin of Brier Hill coal, and this at such a depth that it can be worked by shafts in the valleys with scarcely more trouble and expense than though it cropped out at the surface.

Coal No. 2.

Coal-seam No. 2 lies from 40 to 60 feet above No. 1, in the region where it is best developed, i. e., in the valley of the Killbuck, Holmes County. Here it is a cannel-coal (Strawbridge's), from two to eight feet in thickness. All around the margin of the coal-basin a thin coal-seam marks this horizon, but it is not constantly present, and is much more important in Holmes County than elsewhere.

The Strawbridge coal would be generally classed as a cannel, but it differs considerably in chemical composition from most cannels, and is more like some of those known as "splint-coals" in England and Scotland. It has the structure and aspect of a cannel-coal, but has so large a percentage of fixed carbon, and so little volatile matter, that it is applicable to quite a different class of uses. The Strawbridge coal has as great heating power as almost any of our coals, and would serve an excellent purpose as a furnace-fuel, if it contained less sulphur. This ingredient would preclude its use for the manufacture of gas, even if it were not true—as it is—that it contains less volatile

matter than the "Brier Hill," which is generally regarded as the "driest" of our coals. It will serve a good purpose as a household fuel, though the volume of ash it produces will be, to many, an insuperable objection to it. In this respect, however, it will compare favorably with many of our Ohio cannels, as they generally contain nearly as much ash. I formerly made analyses of all the cannel-coals then known in Ohio, and found none that contained less than 10 per cent. of ash. The Flint Ridge contains 12 per cent.; the purest of the Walhonding cannel, Coshocton County, contains 10 per cent.; the Canfield cannel from 11 to 19 per cent.; while cannel from Darlington, just east of the line of Pennsylvania, contains from 28 to 52 per cent. of earthy matter, and an average of 35 per cent. The latter coal is now largely mined and sold at a price but little below that of our best varieties. The Strawbridge has much greater heating power than the Darlington coal, and ought to command at least an equal price.

The true application of coals like the Strawbridge is to the generation of steam, especially in locomotives. Having no tendency to cake in the fire, and burning as freely and with nearly as little smoke as wood, such coal can be used in a locomotive-engine almost without change in the fire-box. For such use it matters little whether the percentage of earthy matter is a little greater or less, as the ashes are so readily discharged from the furnace.

Coal No. 3 (B).

This coal underlies the lower or blue limestone. It is almost everywhere of workable thickness, i. e., from three to six feet. At Mr. Glasgo's in Western Holmes County, it is cannel, three feet thick, good. At Daggan's mine, Knox Township, it is six feet thick, in nearly two equal benches, one bituminous, the other cannel. In Salt Creek Township, Holmes County, it is four feet thick, bituminous in places in two benches, separated by two feet of fire-clay, in others without partings. In the hills south of Napoleon it shows three feet of coal, in three benches of one foot each, with partings of fire-clay of equal thickness between them. On the east side of the Killbuck, in Mechanic Township, it is true cannel, said to be eight

feet thick, but not worked or so exposed that its value can be determined. Northeast of Millersburg, at Mast's, Collier's, and Chambers's mines, it is about four feet thick, semi-cannel, good; at Harger's Mill, eastern part of Holmes County, five feet thick, part cannel, part bituminous.

In Stark County, coal No. 3 is known as the "Limestone vein," and is worked over a large area. About Canton and north to Greentown it is from three and a half to four feet and a half thick, a tender, caking coal of medium quality.

In Coshocton County this seam of coal acquires unusual importance in Bedford and Jefferson Townships. It is here cannel, and, as we often find this bed, divided into several benches. Its maximum thickness is seven feet, and the best portions are as pure as any cannel I have seen in Ohio.

Coal No. 4 (C. Kittanning).

Coal No. 4, lying below, and No. 5 above, the gray limestone, can be almost always found when sought at the proper horizon, but in Holmes County they are thin and of little value. Both, however, become much more important in passing toward the east. In Holmes County coal No. 4 is not constantly present, and nowhere, that we have observed, does it exceed two feet in thickness.

In the valley of the Little Beaver above New Lisbon, coal No. 4 is seen, a few inches in thickness, buried in a mass of bituminous shale. At Letonia, where the New Lisbon Railroad crosses the Pittsburg, Fort Wayne & Chicago Railroad, No. 4 is a bituminous coal, two and a half feet in thickness, remarkably free from sulphur and ash, in fact one of the purest coals in the State. Here it is extensively coked, and furnishes the fuel used in the successful iron-works in this locality. Still farther north, in the edge of Canfield, Mahoning County, this seam of coal is two and a half feet thick, the upper six inches bituminous, the lower two feet cannel. At Wetmore's mine, in Canfield, it is five feet in thickness, all cannel of good quality. Near Palestine, and at Darlington, Pennsylvania, this is the "Darlington cannel," from 8 to 13 feet in thickness, but containing a large percentage of ash. In the valley of the Little

Beaver, just below New Lisbon, coal No. 4 is represented by 20 feet of bituminous shale.

Wherever assuming the cannel character, this coal-seam has a large percentage of ash, and also contains the remains of fishes and mollusks, thus illustrating the truth of the conclusions to which, from these and other facts, I was years ago led, viz., that cannel-coal owes its peculiar character to the large amount of water in which the carbonaceous matter it contains was suspended; that it was, in fact, formed in the open lagoons of the coal-marshes, where the softer portions of vegetable tissue, perfectly macerated, accumulated with more or less transported sediment and mingled with the remains of aquatic animals.

Coal No. 5 (D, Lower Freeport).

This coal-seam lies above the gray limestone. In Holmes and Tuscarawas Counties it is rarely more than two feet in thickness, and is therefore of comparatively little value.

Near Zoar, in Tuscarawas County, coal No. 5 crops out in a great number of localities, and becomes of much economical importance. It is largely mined at Mineral Point, where it is three to four feet thick, underlaid by a valuable hard fire-clay. After passing Hanover Summit, where it is covered, we have in the valleys of Yellow Creek and Little Beaver an important coal-seam beneath the white limestone, and which is probably identical with Coal No. 5, of the western counties. This is the "Roger vein" of the Yellow Creek Valley, and the "Whan seam" of the vicinity of New Lisbon. The "Roger vein," on Yellow Creek, is three feet in thickness, a caking coal of fair quality. The "Whan coal" is three to five feet in thickness, working large, and free-burning. It has much the appearance of the Brier Hill coal, but contains a larger percentage of volatile matter and more sulphur.

In the vicinity of Millersburg, the distance between the upper limestone and coal-seam No. 6 is in some localities as little as 25 feet, and no coal-seam occurs in this interval. Going eastward, the limestone and sandstone over No. 6 become more widely separated, and about Mineral Point, in Tuscarawas County, this space is something like 70 feet, filled with argillaceous, often

bituminous shale, in which are three seams of coal, the uppermost (coal No. 6) just under the sandstone; the second, 12 to 18 inches thick, 25 feet below, an impure and worthless cannel; the lowest, four feet thick (20 feet lower), a very hard, bright, and excellent coal, containing too much sulphur and too much volatile matter to be advantageously used as a furnace-coal, but very free-burning, and highly valued as a steam-coal. This is known as the "Newberry" coal at Mineral Point, and is worked at the mines of Mr. Holden.

Coal No, 6 (E. Upper Freeport).

This is one of the most interesting and important coals of the series. It lies under the "Mahoning sandstone" and over the upper of the two limestones before referred to. On the western side of Holmes County it has a thickness of two feet. Near Millersburg it is the coal mined by Judge Armor, Mr. Saunders, Day & Chattuck, the Holmes County Coal Company, etc., is from five to six feet in thickness, generally in two benches separated by a slate parting. In the mine of Mr. Saunders the coal is in three benches, the top 15 inches, the middle two feet, and the bottom 18 inches in thickness. At Judge Armor's mine, a half-mile north, there are but two benches, of nearly three feet each, and much alike in quality. The coal of this mine may be considered typical of the seam—breaking irregularly with broad, smooth, black, resinous surfaces, rather tender, and containing considerable sulphur. It is highly cementing in character, and makes a bright and handsome coke if properly treated, but such as holds too much sulphur to make it popular as a furnace-fuel. The faults of this coal will be almost completely corrected by washing. This will remove nearly all the sulphur and the slate that comes from the partings, and will make it possible to produce from it, at small expense, a coke which will be first class in quality. This coal is much liked for the generation of steam, and is the type of a "steamboat-coal" on the Ohio, where the draft in the furnaces is so strong that an adhesive coal is preferred.

In Tuscarawas County, coal No. 6 is seen in all the hills about Mineral Point. It is but little worked there, but is the coal mined by John Black, on the south side of Huff's Run.

It has also been worked for many years on the Zoar Furnace property, on the Davy and Holmes farms, at Mineral Point Station, and at the Tunnel, three miles above. In all this region it is from three and a half to four feet thick, a caking coal of medium quality. In the valley of the Conotten, at New Cumberland, it is five feet thick, the upper bench greatly improved in quality. From this locality it thickens going east, and has been opened at some points in Carroll County, where it is seven feet thick. In the central portions of this county it lies too deep to be reached, as the Barren Measures with their red shales form the surface-rocks.

In Southern Tuscarawas, and in Coshocton County, this seam furnishes most of the coal mined. It is the seam worked at Coal Port, Port Washington, Trenton, etc. In this region it ranges from three to six feet in thickness, and varies considerably in purity, but has a prevailing, I may almost say, constant character as a tender, adhesive, but "strong" and valuable coal. It is well adapted to the generation of steam, and its best varieties are preferred to any other Ohio coal for blacksmiths' use.

In the valley of Yellow Creek, 17 miles north of Steubenville, coal No. 6 is the "Big vein" of Salineville, Hammondsville, and Linton, and ranges from four to seven and a half feet in thickness. It is also the "Big vein" of the Shelton and Arter farms, near New Lisbon. Throughout this region it yields a highly-bituminous, caking coal, containing too much sulphur to be used for gas, but destined, when washed and coked, to play an important part in the future industries of this remarkably rich district. East of New Lisbon, coal No. 6 is less thick, but purer. It is Dyke's Coal, on Camp Run, the coal of the Carbon Hill, Enon Valley, and other mines near Palestine, and is the "*Upper Freeport*" coal of the Pennsylvania geologists. The foregoing complete the lower coal-measures.

Coal No. 7 (F, in the Barren Measures).

This coal lies in the tops of the highest hills in the western part of Holmes County, where it is known as the "Taylor coal," is from four to six feet in thickness, open burning, and very pure. Unfortunately, the area it occupies is small.

Throughout most of Holmes County it is either wholly cut away or left in the summits of the hills. In the Fairfield Hills of Tuscarawas County, which reach up to the Barren Coal-Measures, it is three to three and a half feet in thickness, of rather poor quality. It here underlies the famous Black Band ore of that district. At Salineville it is the "Strip vein;" on Lower Yellow Creek, the "Cumberland" or "Groff vein." In most of Columbiana County it is confined to the highest lands, and is little worked; but at Palestine it is the coal mined by Burnett & Joy, and, like most of the coals of that vicinity, is of excellent quality. It is the Elk Lick coal of Somerset County, Pennsylvania.

This is the highest workable seam of coal in Ohio below the Pittsburg bed, although a thin seam (G), sometimes two feet in thickness, is found above it. It is overlaid by the great mass of colored shales which form the Barren Coal-Measures, and which compose the tops of the hills bordering Yellow Creek, extending thence southward to Marietta.

Their Useful Qualities.—With the exception of the Brier Hill coal, there is probably no seam which along its outcrop, north of the National Road, will supply a first-class furnace-coal. The coal of the upper seams is almost universally cementing in character, furnishing a fuel in many instances well adapted to the generation of steam, and for the puddling-furnace, but such as can only be used in the blast-furnace after being coked. In several localities these caking coals are sufficiently pure to be used for the manufacture of gas—as at Hammondsville, Palestine, Letonia, etc.—but the quantity of sulphur which they contain is generally so large that they require more purification than can be economically effected. It should not be inferred, however, from these remarks, that the immense store of fossil fuel contained in the region under consideration is of such quality as not to be usefully employed in the arts; but it is necessary that some process should be adopted for freeing our coals of the sulphur by which they are so generally contaminated before they will become available for the most important uses, and before their full value will be developed. Here is a field where intelligence and enterprise are capable of producing results of the very highest importance,

not only to the residents of this region, but to the State at large. By the introduction of the improved processes of coal-washing and coking now in constant use in many parts of the Old World,[1] these coals may be made to produce a furnace-fuel quite equal in value to our best open-burning coals. Dr. Newberry does not hesitate to predict that, within a few years, this region will be dotted over with furnaces supplied with fuel prepared in this way.

The cannel-coals, which abound in our coal-measures, all contain as much as 10 per cent. of ash. But for this they could probably be transported to New York, and compete with the English cannel, which is there the favorite and fashionable household fuel, and which sells for from $20 to $25 per ton. But the Wigan English cannel has only about three per cent. of ash, and, while the difference between the heating power of the two varieties is not great, the volume of ash left by our coals would be regarded as an insurmountable objection by those who use the English cannel, not only for its cheerfulness, but its cleanliness.

Our cannel-coals supply a large volume of the best illuminating gas, and they will doubtless be somewhat used for this purpose in the future, but the coke made from them is of inferior quality, and any considerable percentage of it would impair the value of the coke produced in the retorts of the gas companies; and this goes far toward paying the cost of the coking coals they use. In my judgment, the best use to which our cannel-coals can be applied, at present, is for fuel for locomotives. Burning, as the cannels do, so much like wood, they can be used in ordinary locomotive-furnaces with little or no change; and since their heating-power is twice that of wood, and they crop out along the sides of several of our railroads, they seem to me destined to supply the place of wood, now in many places becoming somewhat scarce.

Nelsonville or Straitsville Coal in Perry and Athens Counties.

In every coal-region in which there occurs some one coal-seam of much greater size and better quality than the others, it stamps its character on the region, and the smaller seams are almost entirely overlooked. In the Pennsylvania anthracite regions it is the mammoth bed E that produces nearly all the

[1] Described in *Van Nostrand's Magazine*, April, 1870.

coal; in the Cumberland (Maryland) region, the Big seam H; and in Southwestern Pennsylvania, the Pittsburg seam. In Sunday Creek Valley is found a bed of coal which Prof. E. B. Andrews, the assistant geologist in the survey now in progress, says will doubtless prove to be the finest in the State. In the Report for 1870 he says it is below the ferriferous limestone, which makes it No. 3, or B. The following account of it is condensed from his report for 1869:

The limits of its horizontal range had not then been ascertained, but it was finely developed on Sunday Creek, a branch of the Hocking River on its north side, which empties itself at Athens, in Athens County, and it seems to extend through part of Muskingum, Perry, Morgan, and Athens Counties, and probably farther. It is everywhere of good workable thickness, and over a large area it measures from 6 to 11, and even 12 feet. It is thinner on the north, but on Sunday and Monday Creeks, in Perry County, it is 11 feet, and on the Hocking, in the vicinity of Nelsonville, it is seldom less than 6 feet. There is no doubt it is one continuous seam, as it not only holds uniform relations to the lower rocks, but it has, moreover, been traced from hill to hill. It had not been traced at the date of this Report to the south of the Hocking hills, but it was known to extend a considerable distance south of Nelsonville. It dips below the Hocking River, not far from the mouth of Monday Creek; but it is reached by shafts at points farther down that river.

Thickness.—At Nelsonville, in the northwest part of Athens County, on the Hocking River, the coal measures from six feet to six feet four inches, divided into three parts by thin slates, the lower one from one to two, and the upper one from three to four inches. These partings are generally found to characterize the seam throughout its whole extent, and in this respect it strongly resembles Seam B, as found over very extensive regions in Pennsylvania. In its northern and northeastern extensions the seam grows thicker. At Straitsville, in Salt Lick Township, Perry County the seam measures 11 feet, of which 10½ are coal, with the two thin slates from two to four inches each, the upper bench alone being six feet ten inches of clear coal. Numerous other sections are given by Prof. Andrews

in many other localities with the general remark that the coal is everywhere in this section largely developed, and that every farmer who owns hill-land possesses the coal measuring from 6 to 11 feet thick. The reports of some of the coal companies represent it as even 14 feet thick, and sections of this coal-bed have been exhibited in Chicago 12 feet in thickness, with only two very thin bands of slate.

The natural exposures in this part of the State show a magnificent body of very superior coal, with every advantage for easy mining and drainage. In all the tributaries of Sunday Creek which have the requisite erosion this great seam of coal is found. A vast body of coal can be mined up the dip from this valley, and there is scarcely any limit to the coal which is rendered accessible by the various branches of Sunday Creek. The great body of highlands which constitute the divide between the waters flowing into the Muskingum and into the Upper Hocking is doubtless underlaid with this coal, constituting a vast sheet of 11 feet in maximum thickness on the south, and gradually growing thinner to four and five feet in its northern outcrop, along the Zanesville & Cincinnati Railroad. The value of the Upper Sunday Creek Valley as a coal-field says Prof. Andrews, cannot be over-estimated. Farther north, in Perry County, the coal is seven feet eight inches, and a lower seam appears above water-level. In Newton Township, Muskingum County, both seams are now largely mined, and the coal shipped by the Zanesville & Cincinnati Railroad. The upper seam measures four feet, and the other, which is 22 feet below, measures three feet ten inches. The coal is largely used for domestic purposes and for the generation of steam, and is well spoken of.

It will be seen that this remarkable belt of coal, the Nelsonville seam, which has been traced into Muskingum County, has a very extensive range, having been traced over a belt of country 40 miles long and averaging 12 miles wide. In the northeast, the coal rises in the hills and disappears. To the east and southeast, it dips below all the valleys.

The geographical situation, as proximate to a vast coalless district, extending west and northwest of it for hundreds of miles, its accessibility, its enormous quantity, and superior qual-

ity, and the rare advantages for mining and draining, make this great bed of coal worthy the attention of the people of the State and of capitalists everywhere.

Quality of the Nelsonville Coal.—It is properly classed among the dry-burning coals. The tendency to melt and coke is slight, and the free circulation of air secures the best possible combustion. Although not as highly bituminous as some other varieties of coal, yet the flame is considerable, and the coal makes a very cheerful parlor-fire. It has been in use a long time, and everywhere has the reputation of being a very superior coal for all the uses to which it has been applied. It has been used in rolling-mills at Columbus and Marietta, with strong approval; it is highly estimated for the generation of steam, and it is very popular for household use. The small percentage of ash, the unusually complete combustion, giving a fine blaze and little smoke, the large percentage of fixed carbon, giving great heating power, and the small amount of sulphur to create in combustion sulphurous fumes, all combine to render the coal of this great seam one of the best known coals for all uses.

The present geological survey of Ohio has not yet progressed sufficiently to enable us to give any full account of the almost incalculable quantity of coal found in other workable seams. On Sunday Creek, near Millerstown, Perry County, there are two seams higher than the great one, measuring six and four feet respectively, and there are also in some localities good seams below it. In the eastern part of Athens County is a seam of coal supposed by the geologists of the old survey to be the equivalent of the Pomeroy seam, which measures nine or ten feet in thickness. In the Duck Creek Valley, a seam ranges from five to seven feet in thickness, and all over the southern half of the field there are found seams ranging from three to five feet. Those referred to lie above surface drainage, while the stores of coal which may be found by tracing the seams in their eastern dip remain to be examined.

The Barren and Upper Coal-Measures.

A very important line of observation of the coal-measures of Ohio is that along the Ohio River. The State line crosses

that river at the mouth of Little Beaver Creek, 27 miles above Steubenville and in the lower coal-measures. All the strata of the lower coal group dip below the bed of the river a little above Steubenville; the highest coal-seam of the group E, Upper Freeport, is seen in the bed of the river about one and a third miles above that place, and a little farther down it is reached by a shaft 25 feet deep below the bed of the river, the seam being three feet nine inches thick of good coal.

The Barren Coal-Measures have their outcrop on the river hills about eight miles above Steubenville, and nearly their whole thickness is disclosed in the hills immediately opposite the town. The southern or western outcrop of the Barren Measures on the river on the hill-top is below the West Virginia State line, a distance of more than 260 miles by the river.

The western outcrop of the whole coal-field is at Pine Creek, near the line between Lawrence and Scioto Counties, being 309 miles, by the windings of the river, from the point where it is crossed by the Pennsylvania and Ohio line. The average fall of the river is but five inches per mile. In the chapter on West Virginia the great synclinal or centre of the basin is described as on the Virginia side of the river, from Marietta southward, and running in or near the river from that northward for 45 miles to Fishing Creek. In Greene and Washington Counties, Pennsylvania, it is about under the present water-shed between the Ohio and Monongahela Rivers.

The following is given by H. D. Rogers in the Pennsylvania Report, as the boundary-line of the Pittsburg seam in Ohio: After crossing the Ohio River north of Steubenville, the line of its outcrop from the river hills, he says, pursues a very nearly southwest course to McConnellsville, on the Muskingum River, ranging through near the centre of Jefferson County, the southwest corner of Harrison, the northwest corner of Belmont, and diagonally through Guernsey, into the centre of Morgan County. From the Muskingum it tends more nearly south, encroaching gradually toward the Ohio River, passing a little east of the town of Athens, through the southwest corner of Meigs County, and through Gallia County to the Ohio River, which it reaches a little above Burlington, in Lawrence County. The thickness of the seam is but little more

than three feet near the south end of this area, and there the lower coal-measures are much more important.

A careful topographical survey and map is necessary, however, before the outcrop lines of this and the other seams of coal in Ohio can be made with accuracy.

North of the Muskingum River, too, the boundaries are very much concealed by heavy deposits of drift, and the coal-seams are often difficult to identify. In the vicinity of Wheeling the hills are from 150 to 250 feet in height, and they abound in coal. The Pittsburg seam is here 90 feet above the river, and stretches along the face of the river-hills for 13 miles below the place, when at the mouth of Pike Creek it gradually dips under the bed of the river, the seam being then six feet thick. Four miles west of Wheeling, in Ohio, the same coal appears on the National Road. It is at a higher elevation than on the river at Wheeling, where the seam is six feet thick, and of an excellent quality. On the Ohio River it does not appear again for 136 miles, at Pomeroy. By Dr. Hildreth's section, taken with great accuracy and care at Wheeling, there are in the descending order, first, ten feet of soil, then four separate layers of argillaceous and sandy rocks, in all 44 feet, then two feet of pure coal. Next is a bed of 24 feet of limestone, of different chemical affinities, a portion of which is burned into lime. Below this is the Pittsburg seam, consisting first of two feet of coal, of inferior quality, which is left in as a roof in mining the main coal below. Then one foot of slate clay, which is removed in mining; the main coal immediately below it varies from six to seven feet in thickness, is an excellent quality of highly-bituminous coal, with a compact structure. The Ohio River hills are pierced in many places by gangways, and large quantities of coal have for many years been passed down railways, or inclined planes, into flatboats by which the coal is sent down the river to market. Below the main coal-seam is a layer of about eight feet of slaty clay, similar to that above it, then 15 inches of limestone, then 25 feet of sandstone, and 60 feet of red shale and colored marl, the Barren Measures extending to the bed of the river.

Coal No. 6 appears at Wellsville, 19 miles above Steubenville, of a thickness of six feet, 140 feet above the river, and 76 feet above the lake. At Steubenville it is 150 feet below the

river. From Steubenville to the mouth of Wegee Creek, eight miles below Wheeling, on the Ohio side, the Pittsburg seam gradually sinks 362 feet in 30 miles, being at the rate of 12 feet per mile, the course of the river being south 18° west. The dip of the coal, however, is southwest at the rate of 40 or 50 feet per mile. On the Virginia side the mines are troubled with water, while on the Ohio side the water runs out freely through adits a mile long running west by north, giving a great advantage to the Ohio mines. (Colonel Whittlesey.)

The southerly borders of the Muskingum River, and in fact a very large tract on both sides of the Ohio River, from a point 15 miles below Wheeling, at the mouth of Pipe Creek, to a point 20 miles below the mouth of the Kanawha, nearly 150 miles, is covered with strata of red marl, single layers of which are in many places from 10 to 40 feet in thickness. The vegetable impressions found in these rocks are similar to those of the coal-measures, but the formation contains little or no workable coal.

Dr. Hildreth speaks of this as a curious fact that the coal-deposits are so very thin and rare along this part of the Ohio River; but, with our present knowledge of the series of rocks and the structure of the field, it is what we should have expected, as elsewhere there are only some thin worthless seams of coal in this part of the formation. In the chapter on the West Virginia coal-field further particulars of the coal-measures as they are developed along the Ohio River are given. These red shales, says Prof. Newberry, form a conspicuous horizon, running through the highlands from Marietta to Yellow Creek. At the latter locality they form a great mass of colored shales, and compose the tops of the hills.

The following brief sketch of the upper group of coals in the Ohio subdivision of the Alleghany coal-field is given in a letter from Prof. J. S. Newberry, chief geologist of the State: "The general structure of the lower group of coals in the northern half of the Ohio coal-fields is given in sufficient detail for your purpose in our report of progress for 1870. No report has been made on the structure of the coal-measures of Southern Ohio by Prof. E. B. Andrews, who has had that field under his special charge. He states, however, that he has failed to discover in

Southern Ohio the same system and regularity that we have found to pervade the coal-measures of the area north of the Central Ohio road. It seems scarcely possible, however, that there should be so radical a difference in the structure of contiguous districts, as his report would lead us to believe, and I have little doubt that, when his field has been more thoroughly canvassed, the facts observed will be found to crystallize into a system not yet detected, but which, when made apparent, will better harmonize the somewhat disconnected observations yet made in the Ohio coal-field. It is quite certain that the system which I have described in all the coal-measures north of the National Road, as the order of sequence which I educed from my many years' previous study of the field and in the reconnaissance of 1870, has been thoroughly tested by the veteran geologists, Prof. J. T. Hodge, Prof. J. J. Stevenson, and Mr. M. C. Read, all of whom have been engaged in the study of the geology of the counties within the coal-area. Their observations so fully confirmed mine that the numerical arrangement of the lower group of coals may be accepted as applicable, at least to the northern half of our coal-area, though more extended observations have led me, for convenience sake, to make a slight change in the numbering of the beds; viz., No. 4, the coal-seam lying between the two lowest limestones, proving of workable thickness over a less considerable area than was at first supposed, and No. 5 *a*, above the upper limestone, having a wider range; our former No. 4 is now 3 *a*, and No. 5 *a* is No. 5.

"The Barren Coal-Measures are better shown in the northern than in the southern part of the State, though the horizon which they occupy is well marked from the centre of Columbiana County, southwesterly to the Ohio River, and, as I have before stated, red shales form a feature in the strata of this horizon, by which it may be recognized by the most cursory observation. The Barren Coal-Measures have their most perfect development in Jefferson County, below Steubenville, where all the interval between No. 6, the Upper Freeport coal, and No. 8, the Pittsburg seam, an interval from 503 to 534 feet, is without a workable or even noticeable seam of coal. Going west and south from this region, however, the Barren Measures become less

barren; No. 7 becomes a constant and important seam in the valleys of the Tuscarawas and its tributaries, while 7 *a* and 7 *b*, wanting north and east, are introduced, and become locally of workable thickness.

"The Pittsburg seam, our No. 8 (H), is recognized as the first of the upper series of coal-seams. Its line of outcrop as traced by Prof. H. D. Rogers is essentially correct. It first appears on the west side of the Ohio, on the hill-tops of the northern part of Jefferson County and the southeastern corner of Carroll County. Thence it sweeps out through Guernsey, Muskingum, Morgan, Athens, and Meigs, to Pomeroy. On the Ohio River it outcrops for 36 miles in all the hills between Steubenville and Mound City, which is 13 miles below Wheeling, coming up again at Pipe Creek. In thickness it varies from four feet to eight, usually with two partings, which sometimes separate the coal into three distinct seams. In quality the coal is subject to considerable local variation. It is everywhere a caking coal, and in many places could hardly be distinguished from that of the second level of the Youghiogheny.

"Above the Pittsburg seam we have in Ohio a thickness of 300 or 400 feet of the upper coal-measures; but as the trough of the Alleghany coal-field lies in West Virginia, between Morgantown and Wheeling, our section does not reach to the summit of the series. We have enumerated four coal-seams above the Pittsburg, in Ohio, three of which are thought by Prof. Stevenson to respectively correspond with the Waynesburg, Sewickley, and Redstone.[1] In addition to these there are two or three minor seams which locally assume some importance. On the whole, the upper coal-measures in Ohio, even including the Pittsburg seam, are greatly inferior in importance to the lower coal-measures, both as regards the area they occupy and the coal-seams which they contain. An interesting feature of the upper coal-measures is the great mass of limestone associated with the Pittsburg seam, which sometimes attains a thickness of 70 feet, and in greater or less force is always coextensive with that seam. It should also be said that the upper coal-measures contain strata of hydraulic limestone, which yield a cement equal in quality to any produced in the country. This cement is now largely manufactured by Messrs.

[1] Probably Nos. 32, 25, and 22, in the section.

Parker & Son, at Barnesville, Belmont County, and, so far as quantity is concerned, the wants of the entire country could be supplied from this source. The fire-clays of the upper coal-measures are apparently less valuable than those of the lower series. At least none of the plastic clays have been shown to be equal to that underlying coal No. 3, which is the basis of an industry yielding an annual revenue of more than a million dollars, while the non-plastic fire-clay underlying No. 5 (similar to the Mount Savage), so valuable an element in the manufacture of fire-brick, seems to have no representative in the upper coal-measures."

The Coal-Trade.—The Commissioner of Statistics, of Ohio, reports the following table of the amounts of coal mined in this State for a series of years, as determined by his own inquiries, and by the reports made by assessors. The commissioner expresses the opinion that these estimates are all too low, and that some better system of collecting statistics of this vital branch of productive industry should be adopted:

YEAR.	Bushels.	Tons.	YEAR.	Bushels.	Tons.
1863............	26,887,899	1,075,519	1867	46,703,820	1,868,155
1864............	40,527,291	1,621,091	1868	55,264,392	2,210,575
1865............	34,290,859	1,371,614	1869	54,955,057	2,198,203
1866............	42,130,021	1,685,200			

In Pennsylvania a more successful system for the collection of mineral statistics was begun in 1872, by the collection of reports from railroad companies of the coal carried and consumed by them, supplemented by reports from mines, of which the product was used where mined.

Prof. Andrews enumerates a number of localities in the southern part of the coal-field where coal is mined. At Pomeroy and Syracuse, in Meigs County, the production is estimated at 9,000,000 bushels, or 360,000 tons. The immediate vicinity of Pomeroy, including the West Virginia side, is estimated at 480,000 tons.

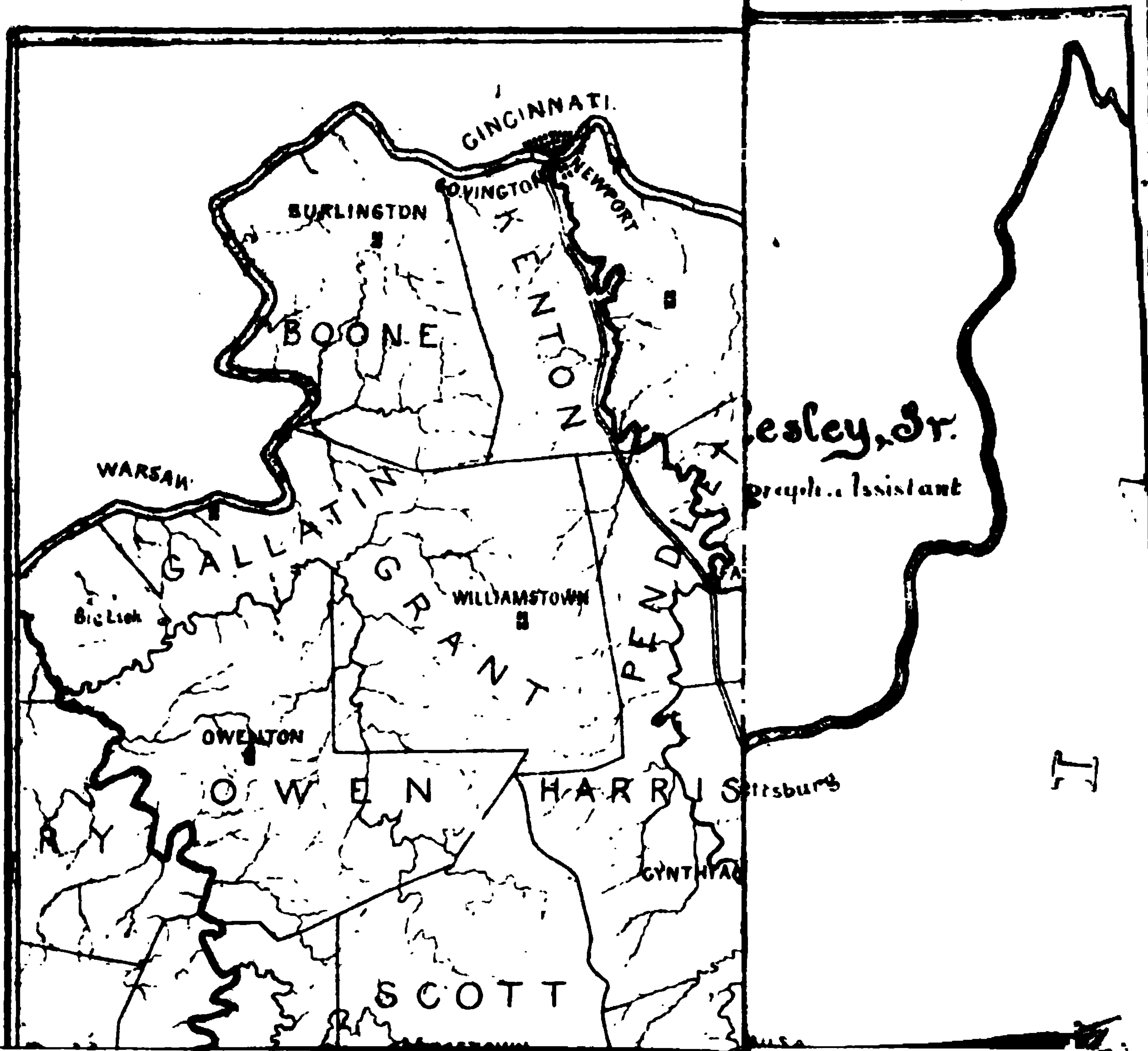
In Athens County coal is largely mined at Nelsonville, and the production has been rapidly increasing since the completion of the Columbus & Hocking Valley Railroad.

Near Haydenville, in Hocking County, are the extensive mines of Peter Hayden. Considerable coal is mined at various

points on the Marietta & Cincinnati Railroad, in Athens and Vinton Counties. At Chauncey and Salina, coal for the salt-works is obtained by shafts from the Nelsonville seam. At Jackson it is largely mined for the blast-furnaces. At Petrea, coal used on the locomotives of the Marietta & Cincinnati Railroad is extensively mined and for shipment. It is also largely produced at Carbondale, in Athens County, and at the Miami Company's mines on the line of the Zanesville & Cincinnati Railroad, in Muskingum County. At Zanesville, and at various points on the Muskingum River, coal is extensively mined for local use, but little is shipped away from the immediate vicinity. A considerable quantity is brought by rail to Hanging Rock, and shipped by the Ohio River. At Sheridan mines, six miles from Ironton, are extensive mines. On Duck Creek a limited quantity is mined for local use, and it is pretty largely mined and shipped in Guernsey County, near Cambridge, on the Central Ohio Railroad. The United States census of 1870 reports the production of coal in the State of Ohio at 2,527,285 tons.

All things considered, the coal-field of Ohio must be reckoned as second in importance only to that of Pennsylvania. It occupies a noble central position in the country, and directly on or near all the great through-lines of travel from the Atlantic cities to the Western States. Its whole eastern border for 308 miles, from Little Beaver Creek to Pine Creek, is washed by that fine navigable river the Ohio, while but a short distance north of it lies the chain of great lakes. Nature has thus supplied it with the best and cheapest water transportation. The features of the country, too, are such as make the construction of railroads through all parts of this coal-field comparatively cheap. Its coal-beds are numerous and of good size, near the surface, easily discovered and traced; mines can be opened with little expense, and the mining requires but little labor. With the exception of the block-coal of Indiana, there is no other coal west of this State equal to that of Ohio in quality, from the river Scioto to the Pacific Ocean. "The iron-district lying between Marietta and Portsmouth exhibits a development of the ores of the coal-measures equalled in no other part of our country." As manufacturers of iron, it may be said we know

not what we shall be. No State in the Union is peopled by a better population, and it is also one of our best agricultural districts. There are important kingdoms in Europe which do not contain within themselves the same elements of prosperity, and the means for the support of so dense a popula tion, as the State of Ohio.


CINCINNATI
COVINGTON
NEWPORT
BURLINGTON
BOONE
KENTON
WARSAW
GALLATIN
GRANT
WILLIAMSTOWN
Big Lick
OWENTON
OWEN
HARRIS
SCOTT

XIV.

EASTERN KENTUCKY.

KENTUCKY is the only one of the United States which contains within its boundaries portions of both the first or Alleghany and the third or Illinois coal-fields. The former covers the eastern, and the latter extends into the western part of the State. These eastern and western coal-fields should be separately considered, the latter coming in properly after Indiana and Illinois.

The approximate boundary of the eastern coal-field is defined in general terms by Prof. D. D. Owen, in the "State Geological Report for 1856," running from south to north. Commencing on the Tennessee line with the spurs of Poplar Mountain, in Clinton County, where it throws off its outliers into Overton County, Tennessee, taking in the southeastern corner of Clinton County, it then takes a northeast course through Wayne County, near Monticello. From the latter place the line runs due northwest through Wayne and Pulaski Counties, by Wallace Mountain and Sloan's Hill, to near the shoals of the Cumberland River; thence to the Big Narrows of Rockcastle River; thence up the valley of that stream nearly along the confines of Laurel, Rockcastle, and Jackson Counties, to where they corner with Madison and Estill Counties; thence to where Contrary Creek empties into the Kentucky River, three miles below its three forks. As a very general description, the line runs thence with a northeast course through Morgan and Carter Counties toward the head-waters of Tygart's Creek; thence down the valley of the Tygart to near its confluence with the Ohio. From the survey afterward made, it appears, however, that the valley of the Kentucky River, from Irvine in Estill, to Proctor in Owsley

County, is under the coal-formation; also, the valley of the Red River in Owsley as far east as nearly to Camptown, and the valley of Licking River up to West Liberty, the coal-formation being confined to two long spurs separating the rivers mentioned. (*See* map, p. 306.)

This coal-field includes 15 counties and parts of five others, and, by the survey made by Joseph Lesley, Jr., in 1858 and 1859, it contains 8,983 square miles. The boundary has a very tortuous course, throwing off innumerable spurs, extending west of the line described. The sub-carboniferous limestone extends along the whole line, but thickening southwestwardly from 70 feet on Tygart Creek to over 400 feet at the Poplar Mountain, in Clinton County. Overlying the sub-carboniferous limestone comes the millstone-grit formation, which may be divided into two divisions, the lower of which is made up of alternating sandstones and shales, enclosing beds of coal and iron-ore, and the upper a massive, coarse-grained ferruginous sandstone, containing pebbles. This upper sandstone is the conglomerate proper, and the underlying strata are the sub-conglomerate, coals, iron-ores, etc., constituting an important part of the treasures of fuel in this part of Kentucky. In the northern part of the field, at Grayson, in Carter County, it is not over 90 feet in thickness, but it increases in a southwest direction, until it becomes 305 feet at the Tennessee line. This and the other formations not only thicken but rise in the air in that direction, being but 500 feet above tide at Grayson, and 1,700 feet in the Poplar Mountain.

In this coal-field the measures admit of a subdivision into two parts, of which the upper corresponds with the lower coal-measures of Ohio, West Virginia, and Pennsylvania; and the other or lower being the sub-conglomerate coals found in all the counties along the margin of the coal-field, and constituting their only coal-seams. The first or upper coal-measures, found in the northern and eastern districts of the field, contain the most valuable and thickest coal-beds, and are remarkably rich in ores of iron, particularly in Greenup County, on the Ohio River.

The general dip of the coal-measures of the eastern coal-field is about south-southeast, or at right angles to the range of the Pine Mountain. This mountain chain, which ranges from the

Shillalies near the Tennessee line, and the southern part of Whitely County, near the confluence of Mud and Clear Creeks, in a north-northeast course through Harlan County to the War Gap, and thence to the Sounding Gap at the corner of Letcher and Pike Counties, has been produced by a great dislocation of the coal-measures, with a nearly uniform bearing, which has heaved the sub-carboniferous limestone more than 500 feet up into the Pine Mountain; thus dividing the Eastern Kentucky coal-field, by a vast longitudinal fault, into two zones, one lying to the northwest and the other to the southeast of this mountain. The former of these belts, though wider in Kentucky, has a less elevation than the latter or southeast belt, which rises, in fact, to a greater height than the Pine Mountain itself, being at least 2,000 feet above the general drainage of the country, and constituting the range of the Log Mountain, and the Big and Little Black Mountains, skirting along the Tennessee line.

The entire thickness of the carboniferous rocks of the eastern coal-field cannot be stated with accuracy, but it will probably not fall short of 2,500 or 3,000 feet.

The analyses of some of the most important coals of this coal-field show:

Moisture....................................	from 2 to 7
Volatile combustible matter....................	from 32 to 38
Fixed carbon..................................	from 58 to 59
Ashes..	from 1 to 5

A brief survey of a few of the counties of Eastern Kentucky covered by the coal-field will give the best general impression as to the coal-deposits. The upper coal-measures of this field (being the lower ones in Pennsylvania) will first be considered. The most northerly coal-producing county is Greenup, and it is the only one on the Ohio River, except Boyd, which is east of it. Greenup County deserves the first place in the whole State for its mineral wealth. It has in abundance beds of iron-ore of excellent quality, thick seams of fat cannel-coal; and with this a most favorable position along the Ohio River, which facilitates the transportation of the products of its mines. There are numerous veins of iron-ore which cover the whole extent of Greenup County, and the northern part of Carter County immediately south of it. This

deposit also extends into the southern part of Scioto County, Ohio, the famous Hanging Rock region. Although they belong to the coal-measures, they can only be noticed here as giving importance to the coal-beds found in the vicinity, some of which, most fortunately, are of the peculiar kind required for the manufacture of iron.

At Coalton, near Ashland, Kentucky, are large deposits of coal remarkably free from sulphur, and which is used in the raw state for smelting iron. The most important furnace in Kentucky in point of production is the Ashland furnace on the Ohio River, in Boyd County, which was built in 1869, and has a yearly production of 12,000 tons. At the time of its erection it was said to be the largest stack west of the Alleghany Mountains, being capable of producing 40 tons daily. This furnace uses the coal from the seam at Coalton. Several other furnaces are projected in this region. A block-coal of a similar character is reported on the Green River, in Western Kentucky.

In Greenup County there is evidence of an upraising of the coal-measures against the Silurian rocks, proving a separation of the great basin by an upheaval posterior to the formation of the coal. Six miles west of Greenupsburg the sub-carboniferous limestone is exposed at the top of a high hill about 400 feet above the Ohio River. A strong dip to the east soon brings it at the level of Tygart's Creek, where it disappears. To the eastward the general dip discontinues as far at least as the mouth of the Big Sandy, and is replaced by gentle undulations, of which the highest points are no more than 30 feet above the general water-level of the country.

Greenup County may be regarded not only as possessing a number of workable coal-beds, but as having probably the thickest strata of cannel-coal in Kentucky. Numerous sections are given in the fourth volume of the State survey, at various localities in Greenup and Carter Counties, particularly at the iron furnaces. There is no question about the general distribution, and the convenient accessibility for mining of the coal-beds, of which the following general section will give a very correct idea. The errors committed in regard to the coal-strata in Kentucky only applied to the western coal-field. The reports of the Eastern Kentucky field are correct in that respect.

The upper coal-measures of Ohio and Pennsylvania are not found in Eastern Kentucky, the southern boundary of that formation crossing the river from Ohio into West Virginia, farther north. The following is Mr. Lesquereux's general section for Greenup and Carter Counties in the descending order. For the sake of uniformity, however, the coal-beds are here designated by the letters used for the corresponding seams in Pennsylvania, Ohio, and West Virginia, placed between parentheses:

STRATA.	Coal, feet.	Rock, feet.	STRATA.	Coal, feet.	Rock, feet.
Mahoning Sandstone.....		50			
Limestone...............		3 to 6	Coal (C). C 1 C..........	3 to 4	
		10			20
Coal (E). C, 3d.........	3 to 4		Blue block-ore...........		
		40	Coal (b). C...............	10 in.	
Bastard Limestone.......					
		20			20
Yellow Kidney I. O......			Coal (B). C 1............	4 to 6	
		10	Shales.....		30 to 45
Lime Kidney............			Coal (A), (C 1 A).........	3	
		15			40
Coal (D). C 2d..........	3 to 4		Kidney Ore..............		6 in.
Black Kidney Ore........			Block Ore................		1 to 3
		60			30
Yellow Kidney..........					50
Limestone and Ore.......					

No trace of coal has been found in Greenup County below the millstone grit or conglomerate.

In Lawrence, Johnson, and Floyd Counties, which are situated south of Greenup and Boyd, along the east line of the State, on the Big Sandy, next the West Virginia line, coal A is found two to three feet in thickness; B is four to six feet thick; D is 2½ to four feet, and E is five feet. Prof. Owen reports the best exposures which he had seen of these coal-measures on the Big Sandy, in Lawrence County, above the mouth of its Louisa or West Fork, and in Floyd County, in the vicinity of Prestonburg, on the same stream, where are four or five different coal-beds. In Lawrence County, south of Louisa, on the Big Sandy, he found six or seven beds of coal, measuring, in the ascending order, two feet, three feet, four feet, 2½ feet, four feet two inches, 3½ feet, and above that a seventh, a cannel-coal bed. In Johnson and Floyd Counties, in other places, he found five or six coal-beds. Near the line between Floyd and Pike Counties numerous beds are seen, the main coal consisting of three members, of the united thickness of 7½ to eight feet. The analysis of the

coals of Floyd and Johnson Counties shows from 30 to 35 per cent. of volatile matter, and 64 to 65 per cent. of carbon, the percentage of ashes being very small, and it is but little changed in form in burning. Profs. James Hall and B. Silliman, Jr., made an exploration of the country along the Tug Fork of the Big Sandy, on the line between Kentucky and West Virginia, south of Louisa, and report five seams of coal from three to four feet thick, and one of them eight feet, subdivided into three parts by thin seams of slate. This is its size and description at Warfield, on Tug River.

Morgan and Breathitt Counties also certainly have a great abundance of coal. Morgan County has two beds of coal below the conglomerate, one of two feet, and the other six inches, situated 15 feet above the first. Those above the conglomerate are: A two to three feet; B, four to six feet; C 2d (D), three to four feet; and C 3d (E), three to five feet. In Breathitt County the section begins above the conglomerate, and its upper coal is at a greater height above the lower, showing a thickening of the coal-measures in going southwest. In Breathitt County, about the centre of the field, coal A is two or three feet; B, from four to six feet; C is six inches; C 2d (D), one to two feet; and C 3d (E), four to five feet thick.

The foregoing will convey a correct general idea as to the natural exposures of the coal-beds in the extreme eastern counties of Kentucky, and will throw some light also on the almost unknown district in the southern part of West Virginia. Much remains to be done in the exploration of all this very extensive wilderness country, not only as to its coal-beds, but in regard to its topography, in reference to the building of railroads to bring its coal to market.

The boundary between the portion of the field containing the coal-measures resting upon the conglomerate, and those counties which only have the sub-conglomerate coals, has not been defined. The west border of this Eastern Kentucky coal-field was surveyed, and it was ascertained that it only has the sub-conglomerate coals, of which the lower seam is generally about two feet thick at its maximum, and the upper one not exceeding one foot, and generally less, with a tendency to an increase in the thickness of the coal-measures, and the number and size

of the coal-seams, as we pass toward the northern line of Tennessee.

On the western edge of the eastern coal-field the conglomerate varies in thickness from 75 to 300 feet, attaining its highest point in Owsley. In Rockcastle County it measures 240 feet. Northward, in Greenup County, it thins out considerably, and nearly disappears, as on Tygart Creek. Six miles northwest of Grayson, from the top of the millstone grit to the sub-carboniferous limestone is only 30 feet. From Greenup County northward through Ohio, in following the western edges of the eastern coal-field, after crossing the river above Portsmouth, the conglomerate again thickens to 300 feet in Hocking Valley, then thins out to a few feet in Licking County, near Newark, and thus it continues in undulations to its northern terminus, where it is 100 to 150 feet. By the recent survey of Ohio, the conglomerate, as it appears around the margin of that coal-field, is even less in thickness, and more irregular than the above description. From this, and the unequal distribution of the coal below the conglomerate, it is evident that the sub-carboniferous measures were broken and much diversified in their general level by currents and other accidents, and that the superposition of the conglomerate was the true and firm basis for a uniformity of distribution, and consequently for the wide expanse of our coal-fields.

"From the general views adopted of the formation of the coal, we must infer," says Lesquereux, "that the materials composing the conglomerate were brought and rounded by the wavy movements of the sea against the shore. Such movements cannot be uniform upon a very extensive area, therefore must the materials carried by the waves be deposited very irregularly. Supposing these movements to have been progressive for a long period of time, as the enormous quantity of heaped materials seems to warrant, large tracts of country must have been separated from the shores in lagoons and marshes, covered with the growth of coal-vegetation. Thus, while the sand and pebbles were heaped around them, they have formed isolated coal-banks of various dimensions. A more general depression brought over the whole formation the upper and true conglomerate generally extended over the whole coal-fields of North America."

Conglomerate coal is not peculiar to Kentucky. In Northern Tennessee, near the limits of Kentucky, Prof. J. M. Safford has observed five seams of coal in this situation, one of which attains in some pot-holes a thickness of five feet. In Virginia, south of the Kanawha, Dr. S. H. Salisbury has seen five beds of coal below the conglomerate, one of which is formed of alternate layers of slate and coal, six to seven feet thick. It has never been observed along the western edge of the coal-measures of Ohio, where in many places the conglomerate attains a considerable thickness, but it appears to be developed at Sharon, in Mercer County, Pennsylvania.[1]

The western margin of the eastern coal-field is described by Joseph Lesley, Jr., assistant in the geological survey, as everywhere marked by bluffs of the conglomerate member of the millstone-grit formation. The carboniferous formation and those underlying them dip to the southeast in a great wave which is not symmetrically formed. This great wave is itself crossed by undulations which rise and fall in a series as it were of cross-waves of no great height and depth, but which, running in a northeast and southwest direction, are quite sufficient to determine the principal lines of drainage out from the mountain country into the plain. All the formations along this western margin, from the Devonian black slate upward to the true coal-measures, thicken and rise into the air in a southwest direction.

The lowest coal, and consequently the one which marks the margin of the field, is a sub-conglomerate coal, varying in its thickness, but persistent throughout the whole extent of the line. He further observes that certain species of trees mark certain geological formations, the beech and red cedar, for instance, being characteristic of the limestone series, while the hemlock, holly, and laurel, mark the conglomerate.

At the northern end of the outcrop-line the conglomerate averages about 90 feet in thickness, and is underlaid with a few feet of shale containing a thin coal. Thin streaks of coal, inlaid in the heart of the solid rock, are found all along the line. In Estill County is a seam of good coal, 27 inches in thickness.

[1] The examinations made by Dr. Newberry, however, along the Ohio and Pennsylvania line, in the late survey, show that the conglomerate a hundred feet thick is below the lowest coal-bed.

A great change takes place in going southward, on the ridge dividing the Red River waters from those of the Kentucky River. The upper member now nowhere exceeds 80 feet in thickness, while the lower has increased to an average thickness of 225 feet, and contains two workable and three thin coal-beds, and three of iron-ore.

The main coal of Pulaski County which has been opened above the shoals of the Cumberland River, varying from four to five feet in thickness, lies 40 feet under the conglomerate sandstone, and yields a coal of excellent quality. Sixty feet below this coal is another coal, also stated by Owen in his first report to be from two to 2½ feet thick, with an intermediate bed of from six inches to a foot, 45 feet above the latter. Later reports give less thicknesses as the general average of these sub-conglomerate coals. These coals lie from 90 to 150 feet above the sub-carboniferous limestone of Pulaski County, and between it and the conglomerate. "It appears, therefore," says Owen, "that the carboniferous flora flourished in greater luxuriance at the commencement of the epoch in the eastern coal-fields of Kentucky than in the western; or else, that the first coal-beds and associated strata suffered less from denudation, while the currents were established that swept in the pebbles and sand that went to form the conglomerate. Be this as it may, the knowledge of the fact of the existence of one bed at least of good workable coal 148 feet above the sub-carboniferous limestone, and 40 feet under the conglomerate of Pulaski County, is of great practical importance to the inhabitants of the mountain counties in Kentucky."

As we proceed toward the Tennessee line along the outcrop we find five seams of coal below the conglomerate, two of which are workable, the lower being known as the McKee seam, and the upper as the Main seam. The average thickness of the sub-conglomerate member of the millstone-grit formation is 200 feet, and the dip of the rocks is to the southeast. The McKee seam is of regular thickness; in the most favorable places it permits the miner to take out four feet nine inches of coal. The main coal-bed of this region varies in thickness from 39 to 54 inches. The base of the conglomerate is 25 feet above the uppermost of these five seams of coal. It measures 80 feet

in thickness, and forms for the most part the capping of the ridges.

Unfortunately, this region is nearly inaccessible, having no railroad, the Cumberland River and its branches not being made navigable. Wayne County also has the five sub-conglomerate coal-seams adjoining the Tennessee line, and west of it a corner of Clinton County.

It is evident that Eastern Kentucky possesses a very extensive and rich coal-field, as well as great quantities of iron-ore, which do not come within our province to describe. There is very little trade, however, in the coal of these eastern counties, except on the Ohio River. A few mines only here and there are worked for the trade of the Kentucky River, navigable for barges in the winter months, and a little around West Liberty, for an occasional transportation on the Licking River farther north. But, except some small trade like this, these deposits of combustible mineral repose in undisturbed security for the benefit of the great valley of the Mississippi at some future time. At present there is neither market nor transportation.

The census of 1870 reports the quantity of coal mined in Eastern Kentucky in that year at 35,488 tons, of which Greenup produced 25,180; Boyd, 2,236; and Clinton 7,148, with a little in Rockcastle.

XV.

TENNESSEE.

Prof. James M. Safford, the State geologist, published an excellent report of the geology of Tennessee, in 1869. A large portion of the surveys and explorations seem to have been made at his own expense, and are a gratuitous but very valuable contribution to the geology of the State. The following account of the topography and geology of the coal-region of Tennessee is abridged from Prof. Safford's work. Some accounts of the present state of the coal-mines in this region are added from other sources:

The boundary-line between Tennessee and North Carolina passes along the summit of a very high range of mountains called the Unaka chain, which has a general elevation of about 5,000 feet above the sea, and parts of it are much higher. The portion of this mountain within the limits of Tennessee will average about 12 or 14 miles wide, varying, however, from two or three to 20 miles.

Passing thence directly westward across the State, we next come to the beautiful valley of East Tennessee. It is bounded on the southeast by the Unaka chain, and on the northwest by the steep declivity of the Cumberland Mountain, the coal-producing table-land to which our attention will be mostly confined. This valley runs across the State obliquely in a southwest course, and its width in the northern part of the State, measured directly across, or in a southeast direction, from Cumberland Gap, is about 55 miles; but toward the southern part of the State its mountain-walls converge and reduce its breadth to about 34 miles through several counties north of the Georgia line.

ORCHARD MT

RIDGE.

SECTION OF THE CUMBERLAND MOUNTAIN, OR TENNESSEE COAL-FIELD, ON A LINE THROUGH NASHVILLE AND KNOXVILLE. FROM PROF. SAFFORD'S GEOLOGICAL MAP OF THAT STATE.

Geological Formations.—3. Trenton, or Lebanon; 4. Nashville Group; 5. Niagara; 7. Devonian Black Slate; 8. Lower Carboniferous; 8*a*. Silicious; 8*b*. Mountain Limestone; 9. Coal-Measures.

we next meet with the elevated and wide-spreading plateau well known here as Cumberland Mountain, a high, broad table-land, the great depository of all the coal in this State. This, as has been frequently described in these pages, is a part of that long northeast and southwest belt of high land extending from near the north line of Pennsylvania, through that State and West Virginia, Tennessee, and Alabama. Unfortunately, it is not known everywhere by the same name, but, as it is always known as the Cumberland Mountain here and in Kentucky and Virginia, we must retain the name, although it is called the Alleghany Mountain in Pennsylvania.

The Cumberland Mountain crosses Tennessee obliquely; the portion of it within the State, the table-land we are considering, though much indented by valleys and coves, is nowhere completely cut in two by them. It would furnish a highway from Kentucky to the Alabama line upon its flat top, along which a traveller might pass without once descending, or even without discovering at any time his elevation.

At almost all points on both sides the surface breaks off suddenly in sandstone cliffs and precipices, which are from 20 to 100, and even 200 feet high. These form along the sides of the table-land a well-defined margin or brow of sandstone. From beneath this very frequently overhanging brow the steep slopes of the sides commence and run down to the low lands. With the exception of the northeastern part of the table-land, the slopes below the cliffs rest mostly on or consist of limestone.

The eastern border of the table-land in Tennessee is comparatively a nearly direct or gracefully-curving line, the indentations made by the streams on this side being hardly noticeable. Along its western border, however, it is remarkably irregular, being scalloped and notched by deep coves and valleys separated from each other by long spurs jutting to the west. These deep indentations, through which flow the different streams that empty into the Cumberland River, give the western outline a very ragged and dissected appearance.

The area of the coal-measures is coextensive with that of the table-land, and occupies an area of 5,100 square miles, or nearly one-eighth of the surface of the State. Along the Kentucky and Tennessee line the table-land is about 71 miles wide,

but farther south it becomes narrower. Along the southern boundary of the State, including Racoon Mountain and Sequatchee Valley, it is 50 miles wide. It includes within its limits the whole of the counties of Scott, Morgan, and Cumberland; the larger part of Fentress, Van Buren, Bledsoe, Grundy, Sequatchee, and Marion; considerable parts of Claiborne, Campbell, Anderson, Rhea, Overton, Putnam, White, and Franklin, and small portions of Warren and Coffee.

It will be understood from this description that this Cumberland Mountain table-land has a broad and generally level top, and stands in well-defined and bold relief above the low lands on each side. Its general elevation above the valley of East Tennessee is from 900 to 1,200 feet, or 2,000 feet above the sea. Its immediate escarpment rises up steeply from the valleys and lower plains to heights varying generally from 850 to 1,000 feet. This description applies to both sides of the table-land. An observer standing upon either its eastern or western margin can have extended and beautiful views of the country below. On the east he can see quite across the valley of East Tennessee to the Unaka chain. On the west side the view is very extensive over a great, flat wooded country as far as the eye can reach. But another very important feature of this table-land remains to be explained, consisting of other mountains as it were placed upon this high table-land, the highest parts of some of them but little if any less than 1,000 feet above the general surface of the table-land. In the northeastern part of the coal-region, the plateau character of the table-land is to a great extent lost by these superincumbent mountains. The average elevation of this portion, called Cross Mountain, above the sea is perhaps not far from 2,800 feet. It forms for many miles, in Anderson and Campbell Counties, the eastern escarpment of the table-land, and is a conspicuous object to an observer in the great valley to the east. Other similar mountains extend farther south on the table-land near the east side, called the Crab Orchard range or group. Prof. Safford also describes certain curious ridges on the table-land, and gives other details which space does not permit to be transcribed; but a few of the other physical features are too important to be omitted.

A little to the east of its centre, the table-land is split, as it

were, by the Sequatchee Valley, cut down lengthwise in its body, dividing it from its middle part southward into two parallel but unequal portions or arms. It is a long, straight, narrow trough, 60 miles long, and from three to five miles wide, extending through Bledsoe, Sequatchee, and Marion Counties. All along, on both sides, it is bordered and overlooked by the high, steep inner edges like great walls, marking out the long valley with singular definiteness.

The arm of the coal-field on the east side of this valley is a long and quite uniform belt or table, from six to eight miles wide, running down into Georgia and Alabama, but cut by the Tennessee River, which forms a deep, narrow, serpentine gorge. It is again cut a little farther north by Running Water Creek, through which the Nashville & Chattanooga Railroad finds a passage. Its broken portions south of the Tennessee River are the Racoon Mountain. There is also a remarkable quadrilateral block of the coal-field detached by the Elk Fork and Cove Creek Valleys.

The celebrated Lookout Mountain stands up boldly just within the southern limits of Tennessee, and runs into Georgia. This is a long, narrow, outlying mountain east of the Tennessee River, closely related, geologically, to the Tennessee table-land.

Along the west side of the table-land are some little mountains and benches, but they contain no coal, and our physical geography must be confined to what relates to the coal-regions. The general geological formations of Tennessee consist of the Potsdam, Trenton, and Nashville, of the lower Silurian age, the Nashville being the equivalent of the Hudson; the Niagara and Lower Helderberg being their middle and upper Silurian, and the Black Slate, the Devonian. Their carboniferous series consists of the silicious, the mountain limestone, and the coal-measures. The black shale of the Hamilton formation is often taken, in Tennessee, as an indication of stone-coal; and, as is usual elsewhere, thousands of dollars and a vast deal of enterprise have been wasted in drifting into it.

The lower carboniferous rocks of Tennessee, consisting of the silicious and mountain limestone, are 1,200 feet thick at their maximum. The silicious group is of vast extent through out the State. The mountain limestone is 720 feet thick in the

southern part of the State, and it becomes thinner toward the north, so that near the Kentucky line it is reduced to 400 feet. The mountain limestone, of course, underlies the whole of the coal-field, and forms the main portion of the table land already described.

To understand properly the twofold character of the Tennessee coal-field, the reader must keep in mind the description already given of the mountain, placed, apparently, upon this table-land in the northeast part of the coal-field, and extending over a part of the east side. This more elevated portion embraces, especially, parts of the counties of Morgan, Anderson, Scott, Campbell, and Claiborne. Within it are numerous high ridges or mountains, that rise above the general level of the table-land, and in which is found a great development of the coal-measures. In these ridges, the conglomerate is depressed below the level of the table-land, and the shales, coals, and sandstones, generally horizontal, or nearly so, are piled up in alternating series to a great height above the conglomerate. Altogether, the coal formation in this part of the State has a thickness not far from 2,500 feet. But it should be understood that nowhere else in Tennessee does the formation present any thing like this volume; nowhere else in this State are there so many coal-beds, or such an aggregate mass of coal. At many other points, however, there is a back bench upon the main conglomerate containing these upper measures. The Main Sewanee, the Kelly, the Haley, the Wheeler and Rockwood veins, Prof. Safford thinks, are all the same bed, and are all above the main conglomerate and included in the upper coal-measures.

The following section of these upper coal-measures of Tennessee is given by Prof. Safford, the letters in parentheses being added, and was taken at Colonel Wheeler's, in Campbell County, about four miles in a southwest direction from Jacksboro'.

	Coal.	Rock, feet.		Coal.	Rock, feet.
Sandstone and Shale top of mountain		349	Sandstone and Shale		395
Coal 6 in. Slate (I)	6 feet.		Coal 3 in. Shale (D)	3 feet.	
Sandstone and Shale		351	Shale and Sandstone		290
Coal may be 6 ft. (H)	4 "		Coal (C)	3 "	
Sandstone and Shale		190	Shale and Sandstone		170
Coal outcrop (G)	1 "		Coal outcrop	1 "	
Sand and Shale		322	Shale and Fire-clay		9
Coal outcrop (F)	1 "		Coal 3 in. parting (B)	5 "	
Shale		6	Shale, etc., to foot of mountain		39
Coal may be 5 ft. (E)	3 "				

The entire thickness of the strata is over 2,100 feet. There are no less than nine seams, of which six show not less than three feet of coal. Probably, other seams exist which do not appear at the surface, as but little mining has been done.

Dr. Safford says he is not prepared to say, as yet, what bed of Lesley's classification the Wheeler coal, the lower five-feet bed in the foregoing table, is to be referred to. If called upon to fix it, provisionally, he would make it bed B; neither was he able to ascertain how high it was above the conglomerate. The small rider, one foot thick, nine feet above it, with shale and fire-clay between, the stigmaria in its floor, and its position in the series with three other good seams, and then 512 feet of Barren Measures with only one-foot seams in it, and the two other seams, apparently in the upper coal-measures, corresponding to the Pittsburg and Greensburg, gives the section a strong general resemblance to our Pennsylvania system; and, if so, the above represents the whole of it. But this is a mere conjecture founded on the appearance of the section. The place is west of the faulted region, and the section clear. This Wheeler coal-seam, B, is a very valuable bed of coal, which appears to lie at the base of the main mountain, upon the table-land, in this northeast section. It has been the main source of the coal used in Anderson and Campbell Counties; it is of an excellent quality, and highly esteemed. It will be developed and extensively mined when the Knoxville & Kentucky Railroad is completed.

Unfortunately, this, the most valuable and important portion of the Tennessee coal-field, was that to which Prof. Safford was unable to give as much attention as to the other more extensive and probably more accessible regions covered with the lower or sub-conglomerate coals.

The sub-conglomerate coals of Tennessee embrace the whole of the coal-region of the State except the northeastern section, and a part of the eastern, which we have already considered. These lower coal-measures are often called, without good reason, false coal-measures, by geologists. Farther north, and on the east side of the Alleghany coal-field, they are found overlying the Cattskill group, and in Rogers's Pennsylvania report they are called the Vespertine coal, but have always

been found very thin, uncertain, and deceptive. Along the west border of the Eastern Kentucky coal-field, however, as we have just seen, they are found to the number of five seams, two of which are workable. They are developed in the southern part of Illinois, and are the only coals found in Arkansas. In Tennessee, according to Prof. Safford's report, they are an important division of the coal-measures, consisting of a series of sandstones and shales, with from one to three or four coal horizons, and the thickness of the formation ranges from a few feet to 300. This applies to the southern, western, and northwestern portions of the table-land, where these sub-conglomerate measures are the only ones available as a source of coal.

Prof. Safford takes up the more southern or southwestern portion or subdivision first, and then proceeds northward. *The Sewanee Division* includes that part of the table-land bounded on the east by the Sequatchee Valley, on the south by the Alabama line, and on the north by White and Cumberland Counties. Coal-mines are here opened at Tracy City, in Grundy County, near the Marion County line, with a branch railroad to the Nashville & Chattanooga Railroad at Cowan, by which coal is taken to Nashville, 87 miles.

The main Sewanee coal-seam is from three to seven feet thick, is 230 feet below the conglomerate cap-rock of the upper plateau, and 371 feet above the mountain limestone. There are four thin seams below this main seam, the lowest being from one to three feet thick, and there are two thin seams above it. In this section, the strata are approximately horizontal, and the measures, which it will be seen are 500 feet, are much thicker than in Kentucky, where, however, they grow thicker, and the coal-seams increase in number and size toward the Tennessee line. There is an intermediate conglomerate, 70 feet thick, 54 feet below the main Sewanee coal-seam.

The lower part of the above section thins out in going northward, from 360 feet to 50 feet, in Grundy County, and has only two thin seams of coal. The coal-seams in this lower part are frequently too thin to work with profit, but often swell out, locally, to thicknesses of three, four, and even nine feet. The quality of the coal is generally good, but varies with

the localities. It is not, as a general thing, highly bituminous; much of it is a solid, cubic, free-burning coal. This lower portion, below the 70-feet conglomerate, extends over the whole of this Sewanee division, and, from the numerous sections and details given by Prof. Safford, it seems to contain quite a large amount of coal. In one of the gulfs at the head of the deep, narrow, cliff-bound valley of Little Sequatchee Creek, there are some heavy local developments of the coal of these lower measures. In one locality it is five feet thick, and, in another gulf, the coal shows itself beneath the cliffs, nine feet thick, and is exposed for 40 feet in an horizontal direction. The upper coal-measures, in which is the Sewanee coal, mined at Tracy City, is estimated to cover one-fourth of this division of the table-land. There is very little of it from Tracy City in a southerly or southwesterly direction as far as the Alabama line, but it extends in a southeasterly, easterly, and northeasterly direction.

The main Sewanee is a valuable bed of coal, and the most reliable one west of the Sequatchee Valley. The coal is of a good quality, semi-bituminous, and contains but little pyrites. Perhaps no purer coal is brought to the Nashville market. It is objected to on account of its being more or less fragile, and its tendency to become fine; but, if properly handled and screened, it is a very desirable coal. Its fragile character is due to its peculiar spumous structure, which has been attributed by some to a sort of crystallization, but which Prof. Safford attributes to a lateral crushing movement of the strata in the vicinity, it being but a few miles to points where the rocks have been greatly disturbed, and this structure is mainly confined to the Sewanee mines. The thickness of the bed at the Tracy City or Sewanee mines varies from 2½ to 7 feet, but it may be regarded as a four or five feet bed. Its proper horizon is from 50 to 75 feet above the lower, or 70-feet conglomerate, before mentioned.

The Sewanee mines at Tracy City, in Grundy County, above described, and the Ætna mines in Marion County, produced by far the greater part of the coal sent to market in Tennessee, in 1869, although there are many other points where coal is mined since the completion of the Nashville & Chattanooga Railroad, through the Racoon Mountain.

The main Ætna or Cliff seam, mined at the Ætna mines, in Marion County, is from 70 to 100 feet below the lower conglomerate, and belongs to the lower coal-measures. At no other point have the coals been so thoroughly explored as here. The following general section, in the descending order, of the strata in the Ætna region, will illustrate the character of the coal-formation over a large area:

1. The upper measures, 220 feet, contain the Walker seam, four feet, uniform good cubical coal; the slate-vein five to six feet, with 18 inches of slate and coal mixed; and the Kelly coal, two to three feet, good cubical coal.
2. The upper conglomerate, a sandstone of 75 feet thick.
3. Then 130 to 170 feet of shale, with two thin seams of coal.
4. The lower conglomerate, 70 to 100 feet.
5. Main Ætna or Cliff seam, average, perhaps, three feet.
6. Lower measures, 288 feet additional to the mountain limestone, containing three thin seams of coal, two of which vary from six inches to three feet.

The above presents a fair summary of the coal-measures of the Racoon Mountain region, showing a further increase, going eastward, in the volume and in the number of coal-beds of the lower measures. Another account of the Ætna mines is given in the latter part of this chapter.

The Ætna mines are in Marion County, near the Nashville & Chattanooga Railroad, and between it and the Tennessee River, in the Racoon Mountain, and 13 miles from Chattanooga. The main Ætna or Cliff seam, which is here mined, is the most important bed in the region, and has been mined at numerous points by different parties, and has a wide spread under the lower conglomerate or Cliff rock of the mountain. The seam is irregular in thickness, ranging generally from 18 inches to four feet, but occasionally sinking to a few inches, or rising in a swell six, seven, or more feet in thickness, and it will average, perhaps, three feet. The structure of the coal is often peculiar, being in laminæ from the fraction of an inch to two inches in thickness, separated by seams of mineral charcoal, and each one made up of small irregular vertical prisms. The coal is of good quality, and in demand, not highly bituminous, contains but little pyrite, and makes good coke.

Proceeding northward from the Ætna mines across the Tennessee River, the Racoon Mountain being south of the river, we come to the Walden's Ridge region, east of the Sequatchee Valley, being the part of the same mountain north of the river. This division, extending to Emery River, has not been as yet sufficiently studied by Prof. Safford, but its general character is indicated by the sections already given. Both the upper and lower measures are present, and the main Sewanee is most likely the principal coal. At many points along the eastern slope of the table-land from the vicinity of Chattanooga to the Emery River, in Morgan County, the coal-beds crop out, and numerous banks have been opened in them, being, doubtless, some of them above and others below the conglomerate.

The strata along this eastern slope are often much disturbed. At a few points the coal-measures are brought down to the valley; at others, detached blocks of the measures, containing coal, lie against the slopes as if they had been pitched over from above. In some places mines are opened in these tilted blocks of coal-measures resting against the slope of the mountain, as at Kinbrough's mines in Roane County. At the top of the mountain just beyond the crest there is an outcrop of coal, appertaining most likely to the same bed. North of Chattanooga there are about a dozen localities south of Big Emery River, where coal has been more or less extensively mined in seams of four or five feet in thickness, but only to supply a limited domestic market. Of these a further account is given at the close of this chapter.

The mines of the Wilcox Mining Company are situated on the southeastern slope of Walden's Ridge, and along the northeast line of Roane County. The coal in 1872 was run over a short railroad to Emery River, at a point where there is always water enough to float barges and medium-sized steamboats. These mines are in these tilted and disturbed portions of the field. Prof. F. H. Bradley reports the coal-seam of workable thickness to be the same which is worked at the Ætna mines, where there are four small seams below it. The position of the mine makes it the best, he thinks, in Middle and Upper East Tennessee, since the navigable waters of the Big Emery

River here come within 1½ mile of Walden's Ridge. More convenient places for mines might possibly be found near Chattanooga, but none such are now worked, and it is reported that the coal-seams in that neighborhood are not in as favorable condition for working as those at the Wilcox mines. The main seam of coal averages rather over than under four feet in thickness, and, by analysis of Prof. Wormley of the Ohio survey, this coal contains 63.10 of carbon, 27.70 of volatile matter, 7.70 of ash, and 1.5 of water. If this be a correct analysis, this is a bituminous coal, whereas all the other analyses hereafter given of Tennessee coals are those of semi-bituminous coal. The region is distinguished by sharp synclinal folds of the strata, and the coal-beds are found lying at a high angle to the horizon.

The Northern or Northwestern Division of the Tennessee coal-region, embracing parts of Overton, Fentress, Scott, Morgan, Putnam, Cumberland, and White Counties, is, according to Prof. Safford, a wide table-land without mountains. These lower measures present similar features throughout from Kentucky to Alabama. They consist of shales and sandstones, the latter sometimes absent, and range in thickness from a few feet to about 200 feet. They contain two, sometimes three, rarely more, seams of coal. These are often too thin for mining, but locally swell out and form valuable deposits from 2½ to four or five, rarely more, feet in thickness. The Poplar Mountain and Upper Cumberland coal-banks in Kentucky are the northern extension of this same series.

The extraordinary development of the sub-carboniferous coal-measures with workable seams of coal in Tennessee, as described in Prof. Safford's work, is fully confirmed by J. P. Lesley, the best Pennsylvania geologist, in the following article, based on the report on the Walden Ridge coal-region by Prof. Bradley, of Knoxville, already referred to:

"The juxtaposition of this Upper Silurian iron-ore of V in East Tennessee with the beds of the coal-measures No. XII. is a striking phenomenon, but one not peculiar to that region. We have before spoken of the great downthrow faults which have brought this result about—faults which run in straight lines for several hundred miles from Alabama to Middle Virginia. It is to these faults that we owe the existence of the

Cumberland Mountain Range and the preservation of the coal-beds. Before these faults took place the coal was elevated from 10,000 to 20,000 feet above the level of the sea, on a plateau covered with eternal snow and ice. When this plateau was cracked along parallel lines running east-northeast and west-southwest, intermediate sections of it dropped to about 3,000 feet above tide-level. The sections which retained their altitude have been eroded of all their coal-measures and of the formations beneath the coal-measures as far down as the fossil ore. Thus on two sides of each crack the ore and the coal lie facing each other. *Geologically* they were separated by an immense interval. *Geographically* they are now but a few furlongs, sometimes but a few yards, apart.

"The coal-measures also have been preserved by the vertical drops of the Cumberland Mountain almost in their total original thickness. There are nearly 3,000 feet of vertical coal-measures west of Knoxville. This is in strong contrast with the state of things in Pennsylvania. Our lowest coal-beds are well known to run along the summit of the Alleghany Mountain range (which is the northern prolongation of the Cumberland Mountain of the Southern States); and the coal-basins which lie behind the Alleghany Mountain in Lycoming, Clearfield, Centre, Cambria, and Somerset, are comparatively shallow, never containing more than the lower 1,000 feet of the whole formation, and often not more than enough to take in the first, or first and second coal-beds. The Pittsburg bed and the upper coal-measures are not preserved to us except in the low country of the Monongahela and Ohio River valleys.

"But in Tennessee the lowest coal-bed comes to the surface at the very roots of the mountain, as if it came out in the workshop grounds at Altoona, or in the Susquehanna River bed at Williamsport and Lockhaven. An immense wall, of alternate cliffs and steep slopes, in all nearly twice the height of the Alleghany Mountain at Lockhaven, stands above; and along these slopes, at intervals from the base of the mountain to its crest, run horizontal outcrops of numerous coal-beds. It is true, none of them are very thick; the largest one yet discovered is but seven or eight feet; the Careyville and Coal Creek beds yield but four feet of coal. But the sum total of mineral fuel

preserved for the use of the inhabitants of the South is practically infinite. Every valley and ravine that issues from the plateau lengthens the outcrops and facilitates access to the beds. In course of time a thousand collieries will be started in the mountain, and a thousand iron-works established on the ores at its foot; a thousand villages, towns, and cities, will grow up in the broad limestone plain before it; a thousand factories and mills will make these towns and villages hum with life; and all this life will base itself on the mountain coal, thus wonderfully preserved from destruction by throes of the earth in ancient days, which would have obliterated every trace of human life from the continent had the divine invention of human life been made."

The same writer examined the lands now owned by the Sewanee Coal Company in Marion and Franklin Counties, about the year 1855, and remarked, in regard to the general geology of the Tennessee coal-region, that he had long since arrived at the conclusion that the conglomerate formation (XII.) so called is not so much a geological individuality as a convenient reference and name. In reality several conglomerates were thrown down in the interval between the growth of the several lower beds of coal. Gravel and pebble-stones characterized the beginning of the coal era, as fine sand and mud its middle ages, and mud and marls its later and last deposits. In the Shamokin anthracite region the five lower coals alternate with six distinct conglomerates, and above the twelfth coal-bed is still another similar one. Along Mine Hill the remarkable conglomerate of the gray-ash bed overlies five or six unworkable coal-beds shut up among the underlying sandstones. In Virginia the development of coals beneath the conglomerate is so remarkable that they have been thrown into an older series, and classified with the great red-shale Vespertine formation.

He was, therefore, not surprised to hear, in this Sewanee region of Tennessee, of four beds of coal below the conglomerate at respective intervals of 10, 50, 20, and 25 feet. None of them were then reported to be commonly of workable thickness, although one of them was said to be three feet. One of these sub-coals was opened on Lookout Mountain near Chattanooga, and on Racoon Mountain and Walden's Ridge.

ANALYSIS OF TENNESSEE COAL.

		Carbon.	Volatile Matter.	Ashes.
Addison's Creek, Cumberland Mountain.......		88.22	9.	7.78
Anderson County, E. Tenn..................	R. O. Curry.	82.	10.	7.
Crow Creek................................	"	77.70	14.	8.30
Sewanee Mining Company....................	"	79.56	14.21	6 25
Kimbrough's, Roane County.................	Troost.	71.	17.	12.
Gillenwater's, Rea County.................	"	69.	14.	17.
Tuscaloosa, Alabama.......................	Tuomey.	80.96	12.96	6.

All of these analyses prove the coals to be semi-bituminous, and containing a large portion of carbon.

The Coal-Mines of East Tennessee in 1872.

In the block of coal-measures lying between Cumberland Gap, in Claiborne County, and Wheeler's Gap, no considerable mines have yet been opened. At two or three points, small pits are occasionally opened for local blacksmithing supply; but twenty-five tons would, probably, be a very liberal estimate for the annual product. In this district, coal has long been known to exist at several points, and often in thick beds. But it is bounded, on at least three of its four sides, by upheavals which carry the underlying sub-carboniferous limestone high on the side, and often to the very top of the border ridge, which has a general elevation of from 500 to 1,000 feet above the adjoining valleys. This structure prevents ready access to the coal-seams, except at the gaps.

At Wheeler's Gap, we reach the line of the Knoxville & Ohio Railroad, whose present northern terminus is at Careyville, just in the mouth of the Gap. At this point, mining on the large scale commenced in 1870, though small workings for local supply had been carried on here for some years previous. At present, three companies are mining and shipping coal here, viz.: Kennedy & Morrow, Careyville Coal Company, and Probart & Sons. The latter firm is now applying for a charter, under the name of the East Tennessee Coal Company.

Product of Campbell County, "Careyville."

	1870.	1871.
Kennedy & Morrow............	1,691 tons...............	4,285 tons.
Careyville Coal Company........	3,200 "	4,000 "
Probart & Sons..		1,400 "

The census report for this county is 16,000 tons.

The workings are all in the nearly horizontal strata of the foot of Cross Mountain. The upturned edges of the underlying strata, which elsewhere form a bounding ridge (Walden's Ridge), so as to hinder access to the horizontal beds, are here cut away, and underlie the valley of Wheeler's Gap. About two miles to the southward, these strata rise again as a ridge, and no further attempts at mining are found until we reach Coal Creek, six miles distant (nine by rail), where Coal Creek Gap gives access to the undisturbed strata. Here, the Knoxville Iron Company, the Coal Creek Coal Company, and McEwen, Wiley & Company, are working successful mines, and others are talked of.

Production of Anderson County, "Coal Creek."

	1870.	1871.
Coal Creek Coal Company	12,000 tons	7,837 tons.
Knoxville Iron Company	15,265 "	11,810 "
McEwen, Wiley & Company	10,074 "	6,956 "
Small mines about Winter's Gap		50 "

The census report of the county is 22,750 tons.

These two clusters of mines are worked in one and the same seam. It is a coking coal, making strong coke, and yielding a good supply of gas. It is in some parts quite sulphurous, but varies greatly in this respect, as well as in other characters.

Several other seams of coal are known here, both above and below the one worked, but no considerable openings have been made upon them. They vary in character, but are mostly coking coals. It is probable that a still lower seam than any yet known will be found in the upturned strata, and of a character suited for use in the furnace in the raw state. As abundant iron-ores exist all through this region, being especially concentrated about Careyville, a location otherwise especially favorable for iron-furnaces, it is very desirable that the horizon of this seam shall be explored.

As we approach Winter's Gap, about 20 miles distant, we find several small openings in different seams, one of which is supposed, though not certainly known, to be the equivalent of that mined at Coal Creek and Careyville. The lower seam of furnace-coal has also been opened recently. Coal and iron are both abundant, and of fair quality. Two locks, of small lift, would make Poplar Creek navigable to Clinch River and the Tennessee. The amount of coal mined here at present is very

small, and only for local use. Before the Knoxville & Ohio Railroad was built, this was the source of all the coal carried to the Knoxville market. One of the seams here opened shows an upper bench of several inches of cannel.

Passing on southward, behind Walden's Ridge, we find occasional openings, but none of any size until we approach D'Armond's Gap, when the Little Emery breaks through the ridge. Near this point, considerable work has been done in former times, for local supply, and to some extent for shipment down the river. At present, Colonel Byrd, of Kingston, is mining a limited amount, and hauling out in wagons. The production of Morgan County (near D'Armond's Gap), Colonel Byrd, is (1871) about 100 tons.

On the outer face of Walden's Ridge, between the Little and Big Emery Rivers, the Wilcox Mining Company is carrying on extensive mining operations, in a seam of good furnace-coal, which, however, does not bear transportation very well, having been partially crushed in the upheaval of the sharply-inclined strata which form Walden's Ridge. The coal is excellent for manufacturing purposes, and for making gas. Other seams on the company's property, behind the ridge, yield a fuel better fitted for transportation.

This same seam is next mined about 12 miles farther south, at Rockwood, in Roane County, for use in the iron-furnace of the Roane Iron Company. The "slack" of the mine is first coked, while the lumps go into the furnace raw. This mine is notable for the immense masses of coal rolled up between the "horsebacks," the chambers being in some cases from 60 to 100 feet high. The average dip of the seam is about 30°.

Production of Roane County:

	1870.	1871.
Wilcox Mining County	220 tons	2,570 tons.
Roane Iron Company	16,000 "	16,000 "

The census of Roane County reports 11,425 tons.

Passing on toward Chattanooga, the next are "Sale Creek" and "Soddy" mines, each working from 40 to 60 hands, and shipping their coal to Chattanooga. The coal from these mines is very fine, burning very readily and freely, and giving a bright

and cheerful fire, much more so than that obtained from other mines in this vicinity. These mines are in Walden's Ridge, Sale Creek, about 28 miles, and Soddy, about 20 miles north of Chattanooga.

At several other points above Chattanooga, small openings have been made, but distance from river transportation has prevented their development. The above-mentioned mines are all along the southeastern border of the Cumberland coal-field. The interior of that field is but thinly populated, and has few facilities for exit of heavy products. Accordingly, no coal is shipped, and but little is mined for local use. Valuable seams are known to exist, but they must await population and railroads.

Proceeding westward from Chattanooga, we have first the Vulcan Mines, 16 miles from Chattanooga, on the Nashville & Chattanooga Railroad, which are being worked. The seam is about two feet thick, the coal being very similar to the Etna coal, and in the same mountain. The production is about 1,500 bushels per day.

The old "Gordon Mines," situated near Shell Mountain, on the same railroad, 22 miles from Chattanooga, which have not been worked for several years, are now (1872) being reopened by a substantial company. The seam is from four to six feet thick, and is an excellent coal. The mine is six miles from the main line, on a branch railroad, with one and a half mile more of narrow-gauge track.

The Battle Creek mines, on the Jasper branch of the Nashville & Chattanooga Railroad, work a seam about two feet in thickness, and get out about 1,200 bushels per day. This coal is said to be somewhat harder than that from the other mines. The Jasper branch connects at Bridgeport, 28 miles from Chattanooga.

By a report received from the Etna mines, in Marion County, in 1872, it appears that they are worked by J. C. Haselton. Five seams of coal have been opened, as before described by Prof. Safford, from three of which considerable quantities of coal have been taken, the other two not having been fully developed so as to test their commercial value. Besides these, other seams have been cut in places where they appeared to be too thin for profitable mining, but, as the thickness of the seams

varies with the distance from the outer edge of the mountain where the openings are made, further explorations may show that they possess a value now unknown. The uppermost seam is known as the "Walker Coal," having an average thickness of four feet. It is favorably known as a household coal, but it is not being worked at present. Next comes what is known as the "slate-vein," which, so far as the openings have been made, varies from five to six feet, but the marketable coal is divided by a layer of slate 18 inches thick, which makes the working not only difficult, but expensive. Then comes the celebrated "Kelly vein," having a thickness of from 18 inches to four feet. It is well known as a bituminous coal of first-class quality, and is extensively used throughout the neighboring States, both for household and manufacturing purposes, and for the production of gas. The coke made from the coal is unequalled in the Southern States for purity and strength, and the iron-works around keep up a constant demand for it. Below this lies the "old Etna vein," from which large quantities of coal were taken before the Kelly vein was opened. Below this is the "Rockwood vein," but further explorations are needed to test its value, as it has only been partially mined for household use.

The average monthly production of these mines, in 1871, was 2,100 tons of coal, or 25,200 per annum. The working-force consisted of 129 men and boys, of whom 54 were miners. Three steam-engines were also employed in draining the mine and hauling the coal, and one self-acting inclined plane. On the western side of the field, the only considerable openings are the Sewanee mines, and others near Tracy City. The Tennessee Coal & Railroad Company is said to be the largest coal company in the South. Their mines are known as the Sewanee mines, in Grundy County, before described. They mined and shipped over their road, in 1871, 2,109,639 bushels, or 84,385 tons of coal, and the company is said to be quite successful in a pecuniary point of view.

The following analyses of Tennessee coals, given in Prof. Safford's work, unlike those given above, are those of bituminous coal. As the eastern margin of the field is a disturbed region, it may produce coals of various qualities, but those of the Sewanee and Etna mines appear to be bituminous:

COUNTY.	NAME OF MINE.	Chemist.	Carbon.	Volatile matter.	Ash.
Grundy	Sewanee	F. Zwicke	65.5	29.	5.5
"	"	W. W. Stewart	59.38	34.5	6.12
"	"	Yaryan	63.5	29.9	6.6
Marion	Upper Seam	W. W. Stewart	59.5	38.	2.5
"	"	"	56.5	41.	2.5
"	Lower Seam	"	49.5	43.	7.5
"	Etna	"	65.	32.5	2.5
"	"	J. J. Pohle	74.2	21.39	4.41
Hamilton	Near Chattanooga	T. Sterry Hunt	63.9	26.8	9.3
"	Sale Creek	W. W. Stewart	56.75	40.75	2.5
Anderson	Coal Creek	"	55.	40.	5.

The Lookout Mountain, which begins south of Chattanooga, just within the boundaries of Tennessee, extends across the northwest corner of Georgia, and terminates at Village Springs, in Jefferson County, Alabama. It is a magnificent ridge of bold precipices of conglomerate rock, under which lie the same sub-conglomerate coal-measures as those found in the Cumberland Mountain. There is plenty of coal in the Lookout Mountain, all along its whole extent, although it is not known that any mines are now being worked here. The Eureka mines, in Lookout Mountain, on the Alabama & Chattanooga Railroad, about 36 miles from the latter place, were worked successfully a few years ago, but they are now idle. They produced a hard coal, which was considered better for grates than manufacturing purposes. The city of Chattanooga contains some rolling-mills which furnish a domestic market for coal. The Roane Iron Company's mill manufactures railroad-iron, and consumes 2,500 bushels of coal per day. At the Vulcan Works rolling-mill about 1,500 bushels of coal are daily consumed in manufacturing merchant-iron, bridge-bolts, car-axles, etc. The coal used at both these mills is obtained from Sewanee, Etna, Sale Creek, and Soddy mines. Dank's machine puddling improvement was introduced into use at Chattanooga, and it is a little remarkable that a committee of the Iron and Steel Institute of Great Britain was sent from England, in 1871, to witness its practical operation at so remote a place as Chattanooga, bringing with them English ores, iron, and other materials. The invention was found to be a valuable one, and was thus brought into use in Great Britain. At the Roane Iron Works, at Chat tanooga, nine furnaces were erected with Dank's improvement. The books showed that 2,820 lbs. of coal were required per 2,240 lbs. puddled bar at the puddling-furnaces, as an average

of three months. This includes the coal required for keeping the furnaces in during the night when they were not worked.

From the details given, an estimate might be made of the present production of coal in Tennessee. Its amount would not be very large; the United States census of 1870 reports it at 133,418 tons, and its importance does not consist in the quantity, but in its showing the opening of a trade which must, in a few years, become very large. It will, hereafter, be looked back upon as the birth and infancy of the industrial life of Tennessee. We have seen coal-regions in Pennsylvania, within ten years, increasing their tonnage from a few thousand tons to hundreds of thousands and millions. It is not improbable that, within the next decade, the valley of East Tennessee will become a vast iron-manufacturing country, with numerous blast-furnaces and rolling-mills bordering its railroads, and with the slopes of the Cumberland Mountain dotted with coal-mines and coke-ovens. The good quality of her semi-bituminous coal, her limestone, and her remarkable deposits of iron-ore, are the basis for cities which may be the Scrantons and Pittsburgs of the South.

XVI.

ALABAMA.

Situation and Extent of the Field.—There is a large coal-field in the northern part of the State of Alabama. There are but narrow intervals separating its various parts, but geologically it is divided into three fields. The Black Warrior is much the largest of these, extending from near the line of Mississippi to that of Georgia, covering the whole of Hancock and Walker Counties, and parts of Tuscaloosa, Fayette, Marion, Franklin, Lawrence, Morgan, Blount, Jefferson, Marshall, Jackson, and De Kalb Counties. Its area, so far as it is at present known, is 5,000 square miles, and its form and situation can be much better understood by an examination of the map than from any minute description of its irregular boundaries.

The Cahawba coal-field lies east of the Black Warrior, and parts of it are in Bibb, Shelby, Jefferson, and St. Clair Counties. It extends on both sides of the river whose name it bears, but principally on the northwest side. Its length is about 75 miles, from four miles north of Centreville, in Bibb County, and converging to a point about 10 miles south of Asheville, in St. Clair County. The field is about 10 miles wide at the southern part, for about 30 miles, and then becoming gradually narrower to its northern extremity, and it contains from 180 to to 200 square miles.

The Coosa coal-field lies on the northwest side of the river of that name, east of the northern part of the Cahawba field. It is 36 miles long and eight miles wide, and contains about 150 square miles. Alabama, therefore, has 5,330 square miles of coal.

The Black Warrior coal-field approaches the line of Missis-

sippi; and Prof. Harper, in his geological report of that State, says that the lower unproductive portion only of the carboniferous formation extends over the line. The coal-measures proper terminate in Alabama, and there cannot be any coal in Mississippi.

Topography.—For the proper understanding of the Alabama coal-field, it is necessary to refer to the general physical features of the country, so far at least as respects the mountains, valleys, and rivers. Prof. Tuomey, the State geologist, gives us the following facts in regard to Northern Alabama:

Every one, who has examined a map of the United States, must have been struck with the apparently anomalous direction of the Tennessee River, when compared with the great hydro-

graphic system of the United States. The Atlantic slope, with its greatest elevation along the Blue Ridge, has its system of rivers flowing directly toward the Atlantic. In Georgia and Alabama, which are beyond the southwestern edge of this slope, where its inclination is no longer felt, the rivers flow south into the Gulf of Mexico. In the west, the Alleghanies constitute the summit of the slope, down which the rivers flow into the basin of the Mississippi. But the Tennessee, after draining the valley between the Alleghanies and the Cumberland Mountains at the southern termination of the latter, turns abruptly west, and then passes directly north through two degrees of latitude before it mingles with the great Father of Waters.

The valley through which the Tennessee enters Alabama is much lower than the continuation of that valley toward the south; it was, therefore, impossible for the river to pursue that course farther. The crest of the ridge on the south of the valley of the Tennessee, in Alabama, is 600 feet above the bed of the river.

The highest points in the State are the spurs of the Cumberland Mountains that cross the line in the northeast, and which are about 1,500 feet high. There is no coal in Alabama north of the Tennessee River, except some very small patches of the extremities of the Tennessee coal-field on top of the hills. This section is occupied by narrow ridges divided by streams which run down to the Tennessee, and these ridges retain their elevation so long as the millstone grit remains unbroken on their tops; when that is removed, they rapidly sink to the level of the valley.

The Tennessee finds a passage through an anticlinal valley separating the Cumberland Mountains from the Alleghanies, for they seem to converge at this point. The magnificent ridge on the east of the river constitutes the eastern part of the Lookout Mountain, an enormous ridge of millstone grit which terminates in a bold precipice at the Village Springs, and the western side of the Racoon Mountain, which falls off gradually into Warrior Creek coal-field. The mountains are separated by Murphy's Valley at the southern extremity, and by the valley of Will's Creek the rest of their length. The Lookout Mountain, seen from the valley of the Coosa, has a fine, imposing appear-

ance, and, when length as well as height is taken into the account, it constitutes the only mountain-range in the State. The tops of these mountains form a plain 10 or 12 miles in breadth, unbroken, except by the narrow valley of Will's Creek, being capped with a thick stratum of sandstone which gives rise to this remarkable feature in these mountains.

On the south side of the Tennessee Valley, the area of drainage is limited by what appears to be a ridge, but which, in reality, is the edge of the lower beds of the coal-measures and millstone grit, for they do not thin out, but are abruptly broken off. They once extended northward, across the valley of the Tennessee River, connecting the coal-field of Alabama with that of Tennessee, as their outliers on the tops of the mountains attest. This escarpment, south of the Tennessee River, extends westward across the State, from Brown's Valley to the Mississippi State line, and forms the water-shed between the streams that flow southward into the Warrior, and those that run into the Tennessee. When a stratum of sand-rock forming the top of a mountain has a long, gentle dip or slope to the south, as in this instance, it will always have a short, steep front to the north. The country, therefore, falls off rapidly from this escarpment toward the Tennessee River. As we approach the northwest corner of the coal-field, Bear Creek, rising in the coal-field with its tributaries, is obliged, like the Tennessee, to seek an outlet toward the west.

It will be seen, at a glance, how completely the upper Warrior conforms to the Warrior coal-field. Rising on the verge of the Tennessee, it runs rapidly southward, over the coal-measures of the basin which it drains. The fall of the Warrior between its source and Tuscaloosa is nearly 1,000 feet, or five feet in one mile, and between that place and Mobile the rivers that unite with the Warrior have a fall of only 161 feet, or five inches in a mile. It is for this reason that the Black Warrior River rises during floods to the height of 50 feet at Tuscaloosa; the water being suddenly checked, and unable to escape with the same rapidity, accumulates as it reaches that city. From the escarpment just described, running east and west, just south of the Tennessee River, this Black Warrior coal-field gradually declines southward or southwestward to

the plains of Alabama, into which sinks the southern extremity of this Alleghany, the best if not greatest of American coal-fields.

The structure of the two smaller coal-fields, the Cahawba and Coosa, is quite different; being situated near the anticlinals to be described, the strata are turned up, as it were, edgeways, or inclined at a considerable angle.

Structure.—The structure of the coal-fields of Alabama may be easily understood. They are disposed in long, and narrow, trough-like depressions, through which the principal streams of the region flow. This is caused by the three principal anticlinals of the strata by which the carboniferous rocks have been lifted up in three lines of unequal length. The principal of these extends from near the northeast corner of the State, southwest to near Centreville, in Bibb County. On the east of this, the Coosa and Cahawba coal-measures are tilted up, and dip south of east, and the same southeast dip continues from Centreville to Rome, in Georgia, while, on the other side of the line, the coal-bearing rocks of Racoon Mountain, the Locust Fork, and those of the Warrior itself, dip in the opposite direction. The next anticlinal is in Blount County, and is shorter. Commencing at the head of Murphy's Valley, it unites with the preceding, at Village Springs. On each side of this the rocks dip east and west.

The third anticlinal coincides with the Tennessee Valley to the great bend near Warrington, in Marshall County, and thence continues on in the same southwest direction, through Brown's Valley, in Marshall and Blount Counties. Although the lower carboniferous rocks are not lifted to the surface far south of Blount Springs, yet the influence of this line of uplift is perceived as low as the junction of the Locust Fork or great eastern branch with the Warrior, where the coal-measures are barely bent upward, and dip in opposite directions. From this simple view of the direction in which the forces acted that have moulded into their present form the carboniferous rocks, and to which are due the courses of the rivers, and all the physical features of the entire region, there will be but little difficulty in understanding the structure of these coal-fields.

The Warrior coal-field dips at Tuscaloosa with a very gentle

angle toward the west. This very small angle of dip is characteristic of the Warrior coal-measures throughout their entire extent, and one is immediately struck with the great difference in this respect between them and those of the Cahawba.

Size of the Coal-Beds.—It will be noticed that the Cahawba field has an important advantage over the Warrior in the greater thickness of its beds. The Warrior beds are not only thinner, but contain troublesome bands of slate. Those of the Cahawba are thick, but the beds have a great inclination or dip, and require more capital in commencing mining operations.

A coal-seam 22 inches thick is worked near Tuscaloosa, from which the place is supplied with coal, to the almost exclusion of wood. The coal appears to be of a crumbling character. On the Mulberry Fork, in Walker County, the coal is harder and of better quality than at Tuscaloosa, and seams of about three feet of clean coal are found, and some much thicker, with bands of slate between the coal-seams, and on Lost Creek four feet of clear coal is found.

In the Black Warrior coal-field Prof. Tuomey mentions several places where coal three or four feet thick was reported, but there seems to be no reliable account of any being measured at that time more than 18 inches thick. From his report, it appears that, although the Black Warrior coal-field covers a large surface, the seams of coal are few and very thin. Persons from the Lehigh Valley, who have visited Alabama, report having seen beds of good coal in the Black Warrior coal-field as much as eight feet thick.

In the Cahawba field, at Lacey's Ferry, is a bed about two miles from the river, which is also about five feet thick; and near Montevallo a bed seven feet thick was examined on a branch of Shoal Creek; and on Lewis Creek a bed of two-yard coal is found, but not of a good quality at the outcrop.

By the report of Mr. Tuomey, the coal in the Cahawba field is reported of the thickness of three, four, and 4½ feet at the various localities. He had similar reports of the seams in the Coosa field being opened two, three, and four feet in thickness.

Mr. Daddow, who visited the Cahawba region about the year

1865, says the coal-seam is about five feet thick at its best condition; but farther south, at Montevallo, near the southern end of the Cahawba field, it is 10 feet thick, but exceedingly impure. He pronounces it the worst coal he ever saw used as fuel, containing, besides much sulphur, about 20 per cent. of ash. On the contrary, the coal mined farther north, nearly opposite, and 20 miles west of Talladega, was extremely pure. The latter, however, from the description of the locality, may have been from the Coosa field.

Farther toward the northeast, he says, "The only seam of coal is 18 inches thick, but very pure and clean." He further reports that "coal has been mined for a considerable period in Alabama, and shipped on the Tennessee, Black Warrior, Cahawba, and Coosa Rivers, also by rail to Selma from Montevallo."

In the Coosa coal-field, on Trout Creek, the seam is 21 inches thick, and is bright, clean, and free from slate. On Broken Arrow, in the interior of the field, Mr. Tuomey examined two beds, each five feet thick of clear coal.

The census of 1870 reports only 11,000 tons of coal mined in Alabama, namely, 10,000 tons in De Kalb, and 1,000 in Shelby County. The second geological report gives the following analyses of Alabama coal, showing it to be highly bituminous:

	Cahawba, Level Bed.	Cahawba, Mulberry Creek.	Cahawba.	Tuscaloosa, southern end of Warrior Field.
Volatile combustible matter	35.51	36.62	34.49	40.60
Fixed carbon	57.42	57.28	60.09	54.07
Ashes	6.31	5.30	4.82	3.09
Moisture	.76	.79	.98	1.18
Sulphur	Trace.	Trace.	.17	1.06

The information to be obtained as to the Alabama coal-regions is meagre. A geological survey is very much needed. As a mere advertisement of the mineral wealth of the State, its expenses would be repaid many fold in the accession of population and wealth from immigration, and the increased value it would give to property.

The Cahawba and Coosa coal-fields are almost surrounded by excellent iron-ore. The subject of this book is coal and coal only. Another volume, at least, would be required to do

justice to the iron-ores of America. It is, therefore, better not to attempt any account of them, however nearly they may be associated with the coal-fields. There are great quantities of red hematite-ore in many localities near these coal-fields, the most wonderful of these probably being the Red Mountain, extending from Elyton, in Jefferson County, from 20 to 30 miles northeastward, into St. Clair County. The fossil ores, which are so thin in New York, increase in quantity near this southern end of our great American coal-field, giving assurance of employment for the deposits of fuel for ages to come, on the very ground where Nature has placed in convenient proximity iron-ore, limestone, and coal.

SECOND COAL-FIELD.

XVII.

MICHIGAN.*

The coal-measures of Michigan rest upon the Parma sandstone, a white or slightly-yellowish quartzose, glistening sandstone, containing occasional traces of terrestrial vegetation. It occupies the geological position of the Ohio and Pennsylvania conglomerate. The occurrence of pebbles at a single locality observed constitutes a faint physical similarity, but in other respects the resemblance is rather remote. Unlike the Ohio conglomerate, it is separated from the upper Devonian rocks by a considerable thickness of calcareous and arenaceous strata. The Woodville sandstone is the cover or capping-stone of the Michigan coal-measures, and is a friable, rather coarse quartzose sandstone, stained more or less with oxide of iron, so that its color varies from white to different shades of red. Both the Parma and Woodville sandstone properly belong to the coal-measures.

The coal-field of Michigan embraces the counties of Saginaw, Shiawassee, Clinton, Ionia, Montcalm, Gratiot, Isabella, and Midland, the greater part of Tuscola, Genesee, Ingham, Eaton, and Bay, being nearly 13 counties, besides considerable portions of Livingston and Jackson, and probably other counties on the north. The southern border of the basin reaches into Jackson County. Beyond, or south of this

* Compiled from the "Geological Reports of the State of Michigan," by Prof. A. Winchell.

seem to be several detached outliers, in which the measures do not attain their normal thickness, though the principal seam of coal is very little diminished. The whole area underlaid by the coal-measures is approximately 187 townships, or 6,700 square miles. Over nearly the whole of this extent of country the measures will be found productive. The railroad map of the coal-regions of the United States given in this volume will show its situation. From all the observations of Prof. Winchell, it appears that the rocks of the coal-measures occupy a shallow basin, the longest axis of which is nearly coincident with the axis of Saginaw Bay. The lowest depression of the carboniferous trough lies beneath a line extending from Ionia County into Saginaw Bay. Here the coal-measures will be found to have the greatest thickness, and the coal-seams will be developed in their largest number and size. The whole thickness of the coal-measures here at East Saginaw, on the Saginaw River, between the overlying and underlying sandstones, is shown by the borings to be 123 feet, containing one seam of three or four feet of bituminous coal. From the sections which are given in the State report, it appears that one persistent seam of coal runs through the whole formation, ranging in thickness between three and five feet, being thinnest near the borders of the basin. Sometimes on the border of the basin the Parma and Woodville sandstone, the top and bottom rocks enclosing the coal-measures, are not more than 15 feet apart, and they are not easily distinguished from each other. Toward the central axis of the basin all the members of the series thicken, and several accessary seams of coal make their appearance. When this occurs, one of the seams is a cannel-coal, about two feet in thickness. Immediately above this seam is a belt of black band, becoming in places highly calcareous, and passing into a black ornamental limestone or marble. The following table presents to the eye the general structure of these coal-measures:

5. Bituminous Shales and Light Clays..................	40	feet.
4. Black Band passing into Black Limestone............	2	"
3. Bituminous and Cannel Coal, two to four seams........	3 to 11	"
2. Fire-Clays and Sandstones..........................	23	"
1. Shale, Clay, Sandstone, and other Coal-seams...........	50	"

The shales of the coal-measures are well stocked with the remains of terrestrial vegetation. Fern-leaves, in a beautiful state of preservation, are sometimes found in the black band.

In speaking of the Michigan carboniferous basin or trough, it must be remembered that all these rocks repose very nearly in horizontal planes, so that the undulations, or ridges, into which they have been thrown, are slight, and these have been more or less worn down. The Woodville sandstone is not everywhere found covering the coal-measures, and the denudation has sometimes extended through it, and in limited areas through the coal-measures, but, in general terms, the whole area will be found productive.

The greatest thickness of coal discovered in the State is on Six-mile Creek, where one seam five feet in thickness of coal, and three others of two feet each, are reported, separated by layers of clay 1½, 2½, and 3½ feet each. Next to this, the greatest thickness of any single seam of coal in Michigan is in Eaton County, which is four feet one inch thick, with three other seams two feet three inches, one foot eleven inches, and eight inches, respectively. The only analysis of Michigan coal, given in the State report, is of the Jackson coal, which gives: carbon, 45; volatile matter, 49; ash, 2; water, 2; sulphur, 2. Its quality is quite inferior, and, as Michigan has very cheap transportation by the great lakes, for Pennsylvania and Ohio coals from Buffalo, Erie, and Cleveland, the market for her own coals is very limited, and altogether local.

SYNOPTICAL VIEW OF THE GEOLOGY OF THE LOWER PENINSULA OF MICHIGAN.

IV.—*Carboniferous System.*

16.	Woodville Sandstone	79 feet.
15.	Coal Measures	123 "
14.	Parma Sandstone	105 "
13.	Carboniferous Limestone	66 "
12.	Michigan Salt Group	184 "
11.	Napoleon Group	123 "

III.—*Devonian System.*

10.	Marshall Group, Chemung	147 "
9.	Huron Group, Portage	224 "
8.	Hamilton Group	55 "
7.	Upper Helderberg Group	354 "

II.—*Upper Silurian System.*

6. Onondaga Salt Group	37	"
5. Niagara Group	97	"
4. Clinton Group	51	"

I.—*Lower Silurian.*

3. Hudson River Group	18	feet.
2. Trenton	32	"
1. Lake Superior Sandstone, Potsdam	18	"

It was long since shown, by Prof. Hall, that nearly every member of the Silurian and lower Devonian systems thins gradually in its westward prolongation; loses something of its arenaceous or argillaceous character, and becomes at the West more calcareous, changes which have generally been regarded as proving the origin of the materials of those groups to have been at the East.

In Michigan, on the contrary, there is evidence that the materials for the upper Devonian and carboniferous rocks were derived from the north. The Helderberg limestones are 350 feet thick at Mackinaw, and not more than 60 feet thick in Monroe County. The Hamilton group, so well developed in Thunder and Little Traverse Bays, is not recognized in the southern part of the State. The Huron group, with its gritstones and flagstones, at Point aux Barges, contains only two strata of flagstones at Grand Rapids. The conglomerate at the base of the Marshall, and the pebbles in it, and the Napoleon groups in the north, are not found in any of the southern outcrops, while, on the contrary, extensive patches of the Marshall sandstone are found firmly cemented by calcareous matter at Battle Creek, Jonesville, and other southern points. The palæozoic rocks of Michigan, then, seem to have been isolated from those of the adjoining regions; their lithological characters are different, the organic contents are peculiar, and their materials have been received from another direction. The paucity of rock-producing materials seems to have continued through the epoch of the coal, the Michigan measures not attaining one-twentieth the thickness of the same rocks in Ohio. The evidence leads to the conviction that the Ohio and Michigan coal-basins were never continuous, and that the waters did

not flow over the separating ridge between the Helderberg period and the drift.

Probably there is not a State in the Union where misguided explorations for coal have not been the means of squandering large sums of money. The popular opinion, that coal must exist in the vicinity of black shales, is almost universal. In Michigan, Prof. Winchell, from whose reports this account is compiled, has had occasion to discourage explorations of this kind—a duty always unpleasant, and, as he says, often met with ingratitude and incredulity. In the northern part of the Michigan Peninsula, black, bituminous shales of the Hamilton group are found, which burn freely, and closely resemble the coal-shales, but they lie 500 feet below any seam of coal.

The largest amount of coal-mining in Michigan is done in the vicinity of Jackson, but the whole production in the State, in 1868, did not exceed 25,000 tons, which was used in railroad locomotives, and for other steam-purposes, the coal being very heavily impregnated with sulphur. The United States census of 1870 reports 28,150 tons of coal mined in Michigan in the previous year—28,000 in Jackson, and 150 in Ingham County. Michigan has vast mineral wealth, but not in her coal-beds.

THIRD COAL-FIELD.

XVIII.

INDIANA.

THE general geological structure of Indiana is very similar to that of Ohio, the principal feature of both being produced by the Cincinnati anticlinal. In Indiana, the oldest rocks, the lower Silurian limestone, appear on the southeast part of the State, dipping westward. Next above occur the Devonian formations, and farther west, and above these, is the carboniferous formation in the southwestern part of the State, adjoining the Illinois line. A recent geological survey has been undertaken in this State, under the direction of Prof. E. T. Cox, and reports for the years 1869 and 1870 have been issued. The State has been very greatly enriched by this survey, by making known the very important and valuable coal-field, and especially the iron-making block-coal.

Extent and Boundaries of the Coal-Field.—The line bounding the Indiana coal-field crosses the Illinois line from Iroquois County, in that State, into Warren County, Indiana, four miles north of Williamsport, where good coal is found, and probably the measures extend about three miles farther north; thence it trends southeastwardly along the eastern boundary of Park; it passes near Greencastle in Putnam and Freedom, in Owen County; it reaches the western border of Monroe County, and passes between Huron and Shoales on the Ohio & Mississippi Railroad, in Lawrence and Martin Counties; it runs near French Lick, in Orange County, and to the mouth of Deer Creek in Perry County, where it crosses into Kentucky. But this line is very irregular, and is marked by numerous

tongue-shaped projections which have been here and there cut across by denuding forces, leaving patches or outliers of carboniferous rocks, with the seams of coal resting on the subcarboniferous limestones far beyond the true boundary of the coal-measures. The coal-field embraces Perry, Spencer, Warwick, Vanderburg, Posey, Gibson, Pike, Dubois, Davies, Knox, Martin, Sullivan, Greene, Clay, Vigo, Parke, Vermilion and Fountain Counties, and parts of others through which the line passes as before described. On the south it adjoins the Ohio River for 153 miles from Rome to the mouth of the Wabash River. The area of the Indiana coal-measures approximates 6,500 square miles, or one-fifth part of the entire State. Prof. Cox reports the coal-measures of Indiana as not greater than 650 feet in thickness, including the millstone grit. In a few localities in this State there are one or more very thin seams of coal below the Archimedes limestone, but no coal of any economical value has yet been found lower than the base of the millstone grit.

THE BLOCK-COAL REGION.

There are, in Indiana, two well-defined zones of coal, the eastern and western zones; and, though an equivalency in some of the seams is clearly traced from one to the other, yet the quality of the coal is quite distinct in each. The eastern zone extends along the border of the field, from the Ohio River, in Perry County, on the south, to Warren County on the north, or from Rome to Williamsport, being about 150 miles in length, with an average width of three miles. The area of the eastern zone is about 450 square miles, or 288,000 acres, and the included coals belong to the bituminous variety characterized as non-coking, or free-burning. The Indiana coal, from this zone, has received the local name of block-coal, a name given to it by the miners on account of the facility with which it can be mined in blocks as large as it is possible to handle. The beds are crossed at right angles by joint-seams that greatly facilitate the operation of mining, which is usually carried on without resort to blasting. Block-coal has a laminated structure, and is composed of alternate thin layers of vitreous, dull, black-coal, and fibrous, mineral charcoal. In the direction of the bedding

lines, it splits readily into thin sheets like slate, but it breaks with difficulty in the opposite direction. Chemically, it does not appear to differ from the coking-coals, but, in burning, it behaves quite differently. Unlike the latter, it does not swell, shoot out jets of gas, nor form a cake by running together; neither does it leave an ash mixed with clinkers, but retains its shape, like hickory-wood, until entirely consumed to a small quantity of white ash, which contains no trace of clinker. In the great majority of mines that have been opened, the block-coal is remarkably free from sulphur and phosphorus. Clay County, Indiana, which was first surveyed by Mr. Cox, has the sub-carboniferous limestone about 10 feet thick, as its oldest rock, and about 30 feet of arenaceous shale over it. The mill-stone grit follows this, which is very variable in its lithological character, and carries two or more coal-beds. It is not represented by a conglomerate, or sandstone, charged with quartz pebbles, from which it is entirely free, but varies from a thick-bedded sandstone, of various colors, to silicious shale. Its lower coal, A, is from one foot to three feet thick, and, at some places, is block or non-coking coal, and at others, coking. Coal B, about 12 to 15 feet higher, seldom exceeds one foot thick. The quality of these conglomerate coals is good, but the seams are too thin to prove remunerative.

Although the coal-measures occupy, comparatively, a narrow strip along the western border of Indiana, they dip rapidly to the westward so as to bring in quite a large number of seams. From Reelsville, in Putnam County, the strata dip to the westward at the rate of 30 feet to the mile, horizontal distance. The coal-measures increase rapidly in thickness as you proceed toward the Wabash River, and for some distance beyond that stream, in Illinois. The seams are lettered from A to N, but there are, as yet, no coal-seams discovered to represent the letters C, D, and E, in a blank space of 263 feet.

The most important coals, from a manufacturing point of view, to be found within the entire limits of the great western coal-field, Dr. Cox pronounces to be those marked F, I, and K, on the following section, which are referred to as "lower block," "main block," and "upper block" coals.

The main "block-coal," I, ranges from three feet eight

inches to four feet four inches in thickness, and the lower K and upper F from one foot six inches to three feet six inches. They were first mined in the vicinity of Brazil, and are found occupying a belt that in Clay County is from three to 10 miles in width, and in length extending from the northern limits of the coal-basin, in Warren County, as far south as the present limits of the survey, and it will probably be found farther south.

Dr. Cox is a strenuous opponent of the doctrine of the equivalency in the coal-beds of the Eastern or Alleghany coal-field, and that of the Western or Illinois, Indiana, and Kentucky field, as taught in the reports of the Kentucky survey. It is well known that the great anticlinal which crosses Western Ohio, Eastern Indiana, and extending across Kentucky and Tennessee, is older than the Carboniferous age, and separated the coal-fields from the beginning. He argues that there is no similarity in the series of coal-beds or their accompanying strata. The following is his general section of the coal formations:

CONNECTED SECTION OF INDIANA COAL-MEASURES.

ROCK.	COAL.		
Feet.	Feet.	Inches.	
43			Drift Hard-pan, and 1½ foot Sandstone.
	4		Coal N (Perring).
81			Fire-clay, Sandstone and Shale.
		6	Coal M.
30			Fire-clay, Sandstone, and Shale.
	7		Coal L (Staunton). Bituminous, caking.
14			Fire-clay, Sandstone, and Bituminous Shale.
	1	10	Coal K, Upper Block.
15			Fire-clay and Shale.
		7	Coal J.
11			Sandstone and Shale.
	4	4	Coal I, Main Block.
12			Fire-clay and Bituminous Shale.
	1	5	Coal H.
25			Fire-clay, Slate, Sandstone, etc.
		5	Coal G.
24			Sandstone and Shale.
	3	8	Coal F, Lower Block.
263			Sandstone, Fire-clay, and Shale.
	2		Coal B.
20			Millstone Grit.
	3		Coal A.
3			
522	28	9	Total.

"Block-coal" is a name used by miners to designate a variety of non-caking, bituminous coal, which was first dis-

covered on the western border of the Appalachian coal-field along the Mahoning Valley, in the State of Ohio, where it is also extensively used in blast-furnaces direct from the mine. In many respects it closely resembles the Scotch "splint" coal; it is free-burning, contains a small amount of white ash, is remarkably free from sulphur, has a splinty fracture, breaks into elongated slabs, and emits a dull, ringing sound when struck with the hammer. The beds of this coal are traversed by nar row vertical fissures, that are nevertheless quite distinct, the main system of which runs a little east of north, and, being crossed at right angles by others, they separate the coal-strata in such a manner that the coal may be mined in large cubes or blocks, which exhibit the whole depth of the bed, hence the probable origin of the name "block-coal." The sides of the blocks are regular, and usually stained with oxide of iron, which is probably caused by the infiltration of ferruginous waters along the joints. When entries are driven across the main joints of the block-coal beds, the face of the mine presents a zigzag, notched appearance.

Block coal has a laminated structure, and splits readily into sheets, that have their surfaces covered with a dull, black, soft, fibrous, carbonaceous matter, resembling charcoal; while, on the other hand, it is difficult to break in the direction opposite to the laminæ; and this fracture exhibits a splinty structure, marked by alternate layers of dull and shining black-coal.

In burning, it scarcely swells, or changes form; and never cakes, or runs together. It is this latter character which gives to the "block-coal" its peculiar value as a fuel for smelting iron-ores, while it has sufficient bitumen, in the form of gaseous matter, to render it highly inflammable; and the blocks retain their shape until burnt to ash, in such a manner as will admit the ready passage of the blast and flame through the entire mass of fuel, ore, and flux. On the other hand, the bituminous caking coals, of which the Pittsburg coal may be taken as the type, swell, and mix together, so that the blast cannot force the flame through the contents of the furnace, and the whole mass becomes chilled for want of sufficient heat to melt the ore.

Dr. Cox's researches in Indiana go to show that that portion, at least, of the coal-measures in which this coal is found, is much

disturbed by horsebacks and other irregularities in the strata. From numerous irregularities to be found in the coal-measures in many localities, he was further led to conclude that the bottom of the large marsh or peat-bog, in which coal-beds were formed, was not an entirely level surface, but was subject to the same changes and inequalities that are to be found in the great peat-bogs of the present day; and that it was traversed by streams, both large and small, in such a manner as to cause an accumulation of carbonaceous matter in one locality, and cut it away in others.

This block-coal seems to be often located in small basins, the coal rising in all directions from the shafts. The strata rise rapidly, and the coal is confined, like that about Youngstown, Ohio, and Sharpsburg, Pennsylvania, to small deposits on an irregular floor. For manufacturing pig-iron, this coal is not surpassed by any in the country. A short distance west of Brazil, the seams of block-coal K and I are brought up by a slight wave in the strata, and are cut out by drift. At Newburg, two miles west of Brazil, the general westerly dip from the axis of the wave has again carried these coals to a considerable depth below the surface at the railroad level, and they are so much reduced in thickness as not to have been recognized in the bores made in search of them at various points between Brazil and Terre Haute.

The mammoth bed L, seven or eight feet thick, is a bituminous coking-coal; and, therefore, cannot be used for smelting pig-iron without coking. When properly and carefully selected from the pyritous bands which are more or less common in this bed, it is a very good article, excellent as a fuel for household use and for steam purposes. It will make, in properly-arranged ovens, a hard, metallic-looking coke that will answer for smelting iron. As yet, the value of this mammoth bed of coal is hardly realized.

A large number of mines have been opened on the block-coal seams around Brazil, in Clay County. This county contains a coal-area of 300 square miles. The total depth of coal, including all the seams, is 28 feet, but some of the seams are not thick enough to mine; a further deduction should be made for outcrops, horsebacks, waste, etc., leaving the available depth

of block and coking coals at six feet. When we take into consideration its convenience to market, and its superior quality as a fuel for smelting iron, it seems to be a very valuable coal. In fact, it should be used only for making iron, notwithstanding that, for heating purposes, and for generating steam, it stands unrivalled in the West, and for the use of locomotives it has no superior. As a blast-furnace coal to smelt iron-ore, it has been amply tested in the five furnaces in Clay County, leaving nothing to be desired. The pig-iron here made, from Iron Mountain and Lake Superior iron-ores, by the use of block-coal as a fuel, commands from two to three dollars more per ton at the furnace than the same grade of pig-iron, made in Kentucky and Ohio, will command in Indianapolis.

The average quantity of block-coal used per ton of iron, during one week, in September, 1869, was 4,042 lbs. per ton, of 2,268 lbs., the selling weight of pig-iron; and the product of a furnace, 191½ tons per week. In the report for 1870, Dr. Cox reports that a ton of pig-iron is made with two tons of block-coal. With improvements in the furnaces, it is believed a better result can be obtained.

The State geological survey has not progressed sufficiently to give us much information of the precise extent of the Indiana coal-field, or as to its structure. It evidently covers at least two counties in width, on the central and western border of the State. Of these, Warren, Fountain, Vermilion, Park, Vigo, Clay, Owen, and Greene Counties, have been hastily examined; Clay, Greene, and Vermilion, only having been actually surveyed. That portion of the basin to the southward and west of those two counties remains to be examined.

Greene County has three-fourths of its surface underlaid with the millstone grit. All the coal-beds east of White River, and over a considerable strip west of it, are either sub-conglomerate or in the conglomerate. For the most part, these coals are of the "splint" or "block" variety, and, though generally in thin seams, are nevertheless of good workable thickness at some localities, and will answer in a raw state for smelting iron. Coals A and B are found of a thickness of from one to two feet, and, in rare instances, three feet thick.

As the coal-measures dip to the west, of course they bring

in the upper beds, and some townships in the western part of the county are underlaid by coal-bed L. There are 360 square miles of Greene County underlaid with coal, of which about 150 square miles is "block-coal" of as good quality as in Clay County. While there is a great development of the coal of the latter county, there is very little mining, as yet, done in Greene County.

North of Greene, and east of Clay, is Owen County, where there is block-coal $3\frac{1}{2}$ to 5 feet thick, of good quality. Parke County, which is north of Clay, has a belt of from two to six miles in width, east and west, and extending north and south through the county, from Clay to Fountain County, containing from one to three beds of block-coal. It is broken into irregular basins by the conglomerate which crosses the belt. In the western part of this county, also, the southwesterly dip of the coal-strata brings in the higher beds which, in this county, belong to the bituminous coking variety of coal, and not suited for blast-furnaces.

The belt of block-coal continues north from Parke County, through the central portion of Fountain County, where it seems to terminate on Shawnee Creek, the seams being from one and a half to two feet thick.

Warren County, adjoining the Illinois line, is the most northern county containing coal, and here the outcrop line, on the northern border of the field, enters the State from Illinois, the line running four miles north of Williamsport, the county-seat.

In Vermilion County, south of Warren, block-coal is also reported by Prof. Cox, covering a considerable area, a part of the mammoth seam, L, here assuming this character. The total thickness of the seam ranges from five to seven feet, separated into two or more seams by thin partings of shale, or fire-clay. The lower part of the bed, from 30 to 36 inches, is good block-coal, and the upper part, above the clay parting, is coking-coal.

The somewhat broken and irregular character of the block-coal deposits of Indiana should create no feeling of disappointment, as this feature is universal in other regions producing the same variety of coal, some of which, notwithstanding, are

among the most productive of all the bituminous coal-regions, and have yielded very handsome profits. The Youngstown (Ohio) and Sharpsburg (Mercer County, Pennsylvania) regions have a trade from Erie and Cleveland, which, in the present state of the coal business of the West, may be called immense, besides a large consumption, by blast-furnaces and rolling-mills in the interior, of this block-coal, from small, detached pocket-beds. Like those of Indiana, they are situated around the border of the larger coal-field, and, for aught we know, they may extend also under the higher coal-seams. The bottom was irregular, and the vegetable matter composing the coal was deposited in these little basins just as they happened to be ready to receive it.

The descriptions by Dr. Newberry, already given, of the Mahoning Valley, or Youngstown region, will be recalled to the mind of the reader by Dr. Cox's descriptions of those of Indiana, of which the foregoing is a brief and general summary.

A portion of the coal-field of Indiana, south of that above described, was afterward examined by Colonel J. W. Foster, of Chicago, an eminent geologist, and the following passages are extracts from his reports on the geology of the district in its economical aspect. His notices of the seams of the ordinary bituminous coal are omitted:

"A portion of the eastern margin of the Indiana coal-field is known to contain a body of 'splint' or 'block' coal, which, while affording an admirable article of fuel for steam and domestic purposes, at the same time affords a fuel which will reduce iron in the hot blast-furnace without the preliminary process of coking. The result has been that, within a few years, numerous lines of railway communication have been opened, and others projected, to bring these coals in contact with the iron-ores, and numerous furnaces have sprung up along the line of their outcrop.

"It was confidently asserted up to the time of the publication of Prof. Cox's Report (1870), that these peculiar coals were restricted to a field of no great area in the vicinity of Brazil, but he showed that they ranged almost uninterruptedly northward to near the northern part of Fountain County, undimin-

ished in force, and probably in undiminished purity. During the past season I have had the opportunity not only of verifying the accuracy of Prof. Cox's generalizations as to their northward range, but I have traced them, almost uninterruptedly, to the Ohio River, the distance of the outcrop being not less than 150 miles; and, if I were called upon to designate what portion of the field I regarded as typical of the highest quality of splint-coal, I should unhesitatingly point to the region of the Ohio River; and yet these coals have been mined for years, to supply neighborhood purposes, without their peculiar qualities having been recognized. About 15 miles from the Ohio River, we meet with the best coal thus far developed in the Indiana series, whether for iron-smelting, the Southern market, or ocean steam-navigation.

"At Staab's (S. 8, T. 4, R. 4), we have this seam exposed in all its perfection. It is three feet three inches in thickness, overlaid by a roof of dark, sandy shale, and underlaid by a white fire-clay. The seam is cut by two systems of joints at nearly right angles, which separate the mass into great quadrangular blocks, often three feet long, and 18 inches broad. So thorough is this separation that, when the base of the seam is undermined, these blocks may readily be pried out. This arrangement greatly facilitates the labor of the miner, who can readily take down four tons a day, with little broken or slack coal. A room in such a coal-seam presents a succession of entering and reëntering angles, or, as the miners express it, 'it is like a Virginia fence.'

"Another feature with regard to this coal is its great purity. You may inspect tons of it without finding any interlineated sulphur, and it is only rarely that a brassy film is to be seen along the joints. If you examine the ashes left by a burning mass, they are as white and flocculent as those of hickory. It has, too, a resinous lustre, with blotches of cannel-like appearance, which we see in the best varieties of Brier Hill. Containing no impurities which are readily acted upon, it will bear stocking for an entire season without loss.

"As a means of comparison, I submit the assay of two famous English iron-making coals, and that of selected specimens of Brier Hill and Massillon:

PLACE.	Fixed Carbon.	Volatile Matter.	Water.	Ash.	Chemist.
Clyde Splint, England..........	59.00	36.80	....	4.20	Mushet.
Worsboro, Yorkshire, England...	60.32	38.18	....	1.50	Mushet.
Brier Hill and Keel Ridge, Ohio..	62.66	32.58	3.60	1.16	Wormley.
Chippewa, Massillon, Ohio.......	57.49	32.38	6.95	3.18	Wormley.
Staab's Indiana................	62.81	30.84	3.91	2.44	Delafontaine.
" "	58.23	37.11	1.86	2.80	"

"From these assays it would appear that a furnace-coal, to have sufficient reducing power, and at the same time all the softness and combustibility of wood, should have from 58 per cent. to 62 per cent. of fixed carbon, with little hygrometric moisture, and few impurities. There should be, too, such a physical structure as to prevent the bitumen from running together in the process of combustion, and cementing the mass. With these coals a greater quantity of iron, in proportion to the fixed carbon, is produced than with anthracite; the quality of the iron is better, and the wear upon the furnace is much less destructive.

"We have before remarked that the peculiar properties of the iron-making coals are dependent, not so much on the chemical composition as the physical structure, by which they are enabled to maintain their form in burning.

"These peculiar coals, to which the term 'block' has been applied, occur near the base of the coal-measures, and can be traced, with occasional interruptions, all the way from the middle line of Fountain County, about 100 miles south of Lake Michigan, to the Ohio River, a distance of more than 150 miles, entirely within the State of Indiana. The conglomerate, for the most part a heavy-bedded sandstone, which rests at the base of the coal-field, crops out in bold ledges, and gives to the country a broken contour. Hence, in the projecting of the older railroads, this region was shunned, inasmuch as deep cuts and fills, as well as high grades and abrupt curves, were required. The projectors were ignorant of the inestimable wealth stored beneath the surface. In 1867, the first furnace was erected, and, soon after, the erection of six others followed. The success of these furnaces and the wide-spread demand for these coals as a domestic fuel led to the organization of new

lines of railway, some of which have been completed, while others are now in the process of construction.

"Before the lapse of ten years, the mining of these iron-smelting coals, instead of being restricted to a single district as at present, will be spread over a zone of 150 miles in extent; and it requires no prophetic vision to predict that, before the lapse of half a century, Indiana will rival Pennsylvania in the amount of her mineral products, owing to the physical and chemical properties of the block-coals, and their adaptation to the manufacture of the higher grades of bar-iron and Bessemer steel.

"The physical characters of the coal are these: There are two systems of joints, traversing the seam perpendicularly, which cut the whole mass into quadrangular blocks two or three feet long, and a foot or more broad, and the miner, availing himself of these natural divisions, after having undermined the base, is enabled to pry out the blocks without a resort to gunpowder. He can easily take down three tons a day. These joints appear to have been formed after the materials entering into the structure of the coal were deposited, and are due to a force acting independently of that of consolidation. Where a considerable area is laid bare by stripping the surface, the seam resembles a tesselated pavement. Viewed in section, the appearance is as though block upon block, each of uniform size, had been piled up by the hands of man, and the drifts have a zigzag appearance. The sides of the blocks are smooth, of a dull-bluish color, and are often stained white with fire-clay, but, if cleft longitudinally, there is seen a mass of mineral charcoal, so slightly cemented with bitumen that it readily cracks on handling. The blocks are splintery on cross-fracture, but longitudinally they come out in thin flat sheets like roofing-slate.

"This coal when thrown on a fire at once ignites with a crackling sound, and burns with a bright-yellow flame, giving off little fuliginous matter. It is non-caking, or, in other words, does not run together, thus affording free air-passages. It is so far free from sulphur that it leaves behind a white or gray flocculent ash, and, subjected to the strongest draughts, it gives no clinker. Hence, it is an admirable coal for locomotives, by

reason of its rapid combustion, its freedom from clinker, and its disposition not to form a hollow arch, which in the fatty coals must from time to time be broken up to afford free air-passages. These qualities, too, insure the integrity of the grate-bars wherever burned. It is sufficiently firm to hold up the burden of a furnace, and the only inconvenience experienced is in the amount of 'dust,' or fine particles of mineral charcoal, which are nearly incombustible. This inconvenience appertains to the coals at present used in the blast-furnace, but it would be absent in the more compressed coals before referred to.

"From careful assays it is ascertained that this coal gives from 57 to 62 per cent. of fixed carbon, a small amount of hygrometric moisture, and a small amount of ash, whose whitish and flocculent character would indicate the comparative absence of the bi-sulphuret of iron.

"The Pittsburg coals differ very slightly in composition from the block-coals of Indiana, and yet we know that they behave altogether differently in combustion. The latter will make iron in a crude state, while the former require that the volatile materials be expelled, and the product used in the form of coke. This difference probably results from the mechanical texture of the coals. In the case of the block-coals there are thin partitions of a cannel-like nature, which prevent the cells filled with bitumen from coalescing and rendering tumid the whole mass.

"These block-coals, we know from experience, when tested in a blast-furnace, have all the qualities of charcoal, combined with a greater reducing power. Two and one-half tons of coal are required to make a ton of iron. They are not quite as strong in fixed carbon as the Mahoning and Shenango coals, where two tons only are required, but they produce a more highly-esteemed pig-metal. What Mushet said in his great work on iron, in reference to a certain Welsh coal, is applicable in every respect to the block-coal of Indiana:

"'To the purity of splint coal it unites all the softness and combustibility of wood, and the effects produced by it in the blast-furnace, either as to the quality or quantity of iron, far exceed every thing in the manufacture of that metal with charcoal.'"

ANALYSIS OF THE COALS OF INDIANA, BY DR. COX.

	Specific Gravity.	Weight of Cubic Foot.	Coke.	Volatile Matter.	Ash.	Fixed Carbon.	Water.	Gas.
Clay County.		lbs.						
Star Mine, Planet Furnace, Block Coal I.	1.264	79.0	64.0	36.0	2.5	61.5	3.5	32.5
Knightsville, T. H. & I. R. R.	1.176	73.5	60.1	39.9	0.3	59.8	9.0	30.9
" "	1.167	72.9	59.0	41.0	2.0	57.0	8.0	33.0
Garlich & Collins Brazil	1.23	76.9	60.5	39.5	3.0	57.5	8.5	31.0
North of Brazil, McClelland	1.28	79.9	56.2	43.8	1.5	54.7	5.0	38.8
Barnet's, south of Brazil	1.25	78.1	58.5	41.5	1.5	57.0	4.0	37.5
Stanton Coal L, 7 feet	1.32	83.0	53.3	46.7	6.0	47.3	7.0	39.7
Greene County.								
McClasick's Coal A, 3 feet	1.19	74.3	64.5	35.5	2.0	62.5	3.5	32.0
Babbit's Coal A, 2 feet	1.24	77.3	61.4	38.6	1.5	59.9	3.0	35.6
Bledsoe's Coal L	1.25	78.2	63.5	36.5	0.5	63.0	7.0	29.5
Park County.								
Buchanan, I, 4 feet	1.23	77.0	64.5	35.5	2.0	62.5	4.5	31.0
Batty's Coal K	1.23	77.0	58.5	41.5	2.5	56.0	8.0	33.5
Fountain County.								
Thomas's Coal K	1.23	77.0	64.3	35.7	6.5	59.8	3.0	32.7
Vermillion County.								
Mill Bank, L	1.29	80.5	52.2	47.8	4.5	47.7	3.5	44.3

It has been said, when we analyze mineral waters, we dissect a corpse. So also from the analysis of coal we can learn much, but not every thing. We find in it carbon and hydrogen, its useful constituents, with other volatile substances and ashes, but how are these elements combined? Analysis shows us the materials of which the coal is composed, but not how they are put together. But besides the chemical composition and the indefinable combinations, and possibly unknown substances, which chemistry has not yet been able to detect or describe, the mechanical structure of coal is of the greatest importance. Much of its value for some purposes, and its heating power and intensity, depend on this. Unexpected good or bad results are sometimes produced from the use of coal, and therefore the best proof of its value for a given purpose is a practical test by the use of a considerable quantity. The work of the chemist, however, although it does not teach every thing, is of the greatest value, and men calling themselves "practical," and affecting to despise science, give the best evidence of ignorance and folly. The most scientific are the most practical men, for strength or force must be guided by sight.

"There are some disadvantages in working the block-coal.

The coal-seams are thin, three and a half feet being about the average thickness of the Indiana block-coal. The seams are also more unstable than other coals, there being more faults, horsebacks, rolls, and troubles of all sorts, than are found elsewhere. The coal-beds unexpectedly thin out to an unworkable size, and there is no means of knowing whether the difficulty is temporary or permanent. On the other hand, it has an advantage in mining, in the comparatively slight amount of work required to wedge down a large quantity of coal, after it has been undermined, on account of the natural partings which separate it into the square blocks from which the name is derived. The vertical sutures of this coal, as well as those of the same kind in Ohio and Pennsylvania, are filled by clayey washings from the superincumbent strata, giving the coal a bluish, dirty look. This does not interfere with its burning qualities at all. Even for iron-making the "clay-marked" coal is often preferred, from having less sulphur than the darker, harder, and handsomer coal, that sells better for domestic purposes."—(*Engineering and Mining Journal.*)

There is a general similarity in several respects among all the various regions which produce this peculiar variety of "block-coal," namely, that district near the western line of Pennsylvania, near Sharpsburg, in Mercer County; that near Youngstown, Ohio; this Clay County (Indiana) region, and the Big Muddy district, in Jackson County, in Southwestern Illinois. The resemblance or peculiarities of these consist—1. In their all lying in a northeast and southwest course from each other, thus fulfilling the general law of the northwest gradation in the various kinds of coal, which, however, does not extend beyond the Alleghany coal-field, where its presence was first pointed out by H. D. Rogers; 2. All these block-coal regions lie on the borders of the large fields of coal, those of Pennsylvania and Ohio on the northwest border of the Alleghany, the Indiana on the east side, and the Big Muddy on the southwest border of the Illinois coal-field; 3. They are all in rather small, detached, bowl-like basins, all subject to "horsebacks" and other similar characteristics as to their seams; 4. Their seams are all about the same thickness, and are all low down in the series, although not identical; 5. The analysis, the mechanical

structure, general appearance, and useful qualities of the coal are the same. It is well to place facts of this kind side by side, but it becomes us to be cautious and not too hasty in declaring universal laws, which later discoveries may at any moment overthrow.

"The western zone of coals in Indiana comprises by far the greatest area of measures, being somewhat over 6,000 square miles, and contains three or more very thick beds of coal, besides a number that are too thin for working. Its eastern boundary, which is formed by the zone of block-coal, is irregular in outline, and, with our present knowledge of the geology of the country, it cannot be well defined. It is evident, however, that the block coal-beds, as we go west, are changed in character, and pass into caking-coal. The lower members thin out, and are no longer of workable thickness, even before reaching the Wabash River. Of this we have abundant proof by the three deep bores made at Terre Haute.

"This thinning out of the coal-seams as we go west toward the centre of the basin is a remarkable feature. A few miles west of the Indiana line, in Clark County, Illinois, bores have been made in searching for petroleum, to the depth of 800 feet, without passing a single workable seam of coal, and the two or three thin seams reported in some of these bores are in the upper part of the measures.

"Judged by the dip of the coal, on both sides of the river, the Wabash runs on a slight anticlinal axis, and Dr. Cox believes this to be the case from Attica, in Fountain County, to its mouth in Posey County, and that along its course it cuts through the same strata of rocks, from the bluff at Merom to its confluence with the Ohio River.

"Near the eastern boundary of the zone of caking-coals in Indiana, we find coals K and L, and sometimes N, of good workable thickness, averaging from four to eight feet, and in one locality, in Pike County, there is a bed, not yet studied, but thought to be K, that attains to the thickness of 10 feet or more. Taken altogether, the maximum thickness of these beds may be estimated at 20 feet, and will yield an average, over the greater part of the district, of 10 feet of coal. At some localities the caking-coal is of inferior quality, and largely contaminated

with pyrites, which is so generally disseminated through the seam that it is impracticable, in mining, to separate it from the coals. In many of the counties, however, within this zone, the caking-coals will compare very favorably with the caking-coals of the Pittsburg district.

"Coal K, at Washington, in Daviess County, is a bright, rich-looking coal, quite free from sulphur, is extensively mined, and meets with a ready market at St. Louis, and all the towns along the Ohio & Mississippi Railroad. This coal is used by the gas companies at St. Louis and Vincennes, and, both as to yield and illuminating quality of the gas produced, it holds an average rank with the gas-coals that have been tried at these places. Its specific gravity is 1.294; a cubic foot weighs 80.87 lbs.; by analysis it yields: fixed carbon, 60.00, ash, 4.50, volatile matter, 35.50. The coke is bright, porous, and slightly laminated. The percentage of coke in the caking-coals of Indiana ranges from 52.00 to 64.50, and the ash from 0.50 to 7.00 per cent.

"In Perry, Spencer, Warrick, Vanderburg, Gibson, Pike, Daviess, Sullivan, Genesee, Clay, Vigo, Parke, Vermilion, and Fountain Counties, there are seams of rich-looking and pure caking-coal which have for the most part been but recently developed by the survey, and I feel assured in saying that they will prove to be good gas-coals when subjected to a practical test on a large scale. The chemical analysis of a coal is not always a safe guide for determining its value for gas-purposes.

"From her geographical position, and more especially on account of the extent and value of her coal-beds, and the peculiar adaptation of this coal to the metallurgy of iron and steel, which now forms one of the leading industries of the world, we can safely predict for Indiana a bright future as a manufacturing State. The commerce of the new far West, which is increasing with a rapidity unprecedented in the growth of empires, will just as naturally look to Indiana for its supply of iron and steel, with which to keep up the system of railroads traversing the great plains to the Pacific Ocean, as the old West formerly looked to Pennsylvania. In Indiana, we find the last great belt of timber suited for manufacturing purposes, and after crossing her borders, from thence to the Pacific Ocean, no coal

has yet been found that can successfully be used in the manufacture of iron."—(*Cox's Report*, 1870.)

The United States census of 1870 reports the production of coal in Indiana, in the preceding year, at 437,870 tons, of which 236,642 tons were from Clay County, and 64,338 from Daviess County. On taking a general survey of the Indiana coal-field, after the following account of the large portion of the same deposit in Illinois, the reader will probably be agreeably surprised to find this State provided along its western border with so admirable a coal-region. Its great advantage consists in the good quality of its coal, especially the "block-coal," of which such frequent mention has been made. Although the character of these seams is less persistent than some others, yet the quantity of this description of coal is evidently quite large. Besides this, there is in Indiana a very large quantity of the more common variety of bituminous caking-coal, particularly coal L, the mammoth seam, seven feet thick. When all the coal-seams are fully developed, there are eleven of them, of which five are more than three feet thick. The first from the surface is four feet; the third, seven feet; the fourth, which is the most valuable, the main block-coal, is four feet four inches; and another block-coal seam, F, is three feet eight inches. The lower two are in the millstone grit. As respects quality, quantity, and accessibility of its coal, Indiana is more fortunate than any of the Western States; and these, according to the treatise on the coal-trade found in the latter part of this volume, are the three prime requisites of a valuable coal-region.

XIX.

ILLINOIS.

It is remarkable that the first discovery of coal in America, of which there is any account in any printed book, was made so far in the interior as Illinois, by Father Hennepin, in 1669, more than two hundred years ago. On the map, illustrating his journal, published in 1698, he points out a "coal-mine" on the Illinois River, near where Ottawa now is, and in his journal he says there are "mines of coal," referring to the outcrop appearance of coal on the surface. "This," says R. C. Taylor, "is the earliest notice on record of the existence of coal in America."

The coal-bearing strata, or coal-measures, comprise a larger area of coal-lands than can be found within the boundaries of any other State in the Union. The carboniferous system of Illinois, including the coal-measures, the conglomerate, and the lower or sub-carboniferous limestones, attains a maximum thickness of at least 2,500 feet, and underlies about three-quarters of the whole area of the State. The coal-measures proper, or coal-producing rocks, however, included in the above, are only about 500 feet in thickness. There is also some coal found in the conglomerate in the southern part of the State, but the conglomerate coals are seldom sufficiently developed to make them of any practical value except to supply the immediate neighborhood where they occur. The following vertical section of the Illinois rocks is given in the State Geological Reports,[1] from which this account is an abstract:

[1] Geological Survey of Illinois, A. H. Worthen, Director. 4 vols., 4to. Published by authority of the State of Illinois: 1866, 1868, and 1870. Assistants: J. D. Whitney, Leo Lesquereux, Henry Engelman, H. C. Freeman, H. M. Bannister, Frank H. Bradley, H. A. Green, and, in Palæontology, J. S. Newberry.

VERTICAL SECTION OF THE ILLINOIS ROCKS.

	Post-Tertiary—Drift-lias, Clay, Sand, Pebbles, Bowlders, etc.	150
	Tertiary—Eocene Period	150
Carboniferous and Sub-Carboniferous.	Coal-Measures and Millstone Grit	600 to 1,200
	Chester Group—Limestone, Sandstone, and Shale	500 to 800
	St. Louis Group—Limestone and Shale	50 to 200
	Keokuk Group—Limestone and Shale	100 to 150
	Burlington Group—Coarse, Sub-carboniferous Limestone	25 to 200
	Kinderhook Group—Shales, Limestone, and Sandstone	100 to 150
Devonian.	Hamilton Period—Black Slate	10 to 100
	" " Devonian Limestone	10 to 120
	Oriskany Sandstone	40
Upper Silurian.	Oriskany, Lower—Clear Creek	200
	Lower Helderberg—Magnesian and Argillaceous Limestone	200
	Niagara Period—Magnesian and Argillaceous Limestone	200
Lower Silurian.	Cincinnati Period—Shale, Lime, and Sandstone	140
	Galena and Trenton Limestone	800
	St. Peter's Sandstone } Potsdam.	150
	Calciferous, or Lower Magnesian Sandstone } Potsdam.	120

Boundaries of the Illinois Coal-Field.

The following description of the outcrop line of the Illinois coal-field is derived from the geological reports of the counties, and from a map furnished by Prof. Worthen, the State geologist. Beginning at the southeast corner, on the Ohio River, in the northeast corner of Hardin County, two thin coal-seams underlie a very limited area. In the northwest half of Pope County, sub-conglomerate coal is found, and the same is continued through the northern part of Johnson County. There is no coal in Union County. A line drawn through Johnson County, from the southeast to the northwest corner, would very nearly define the western boundary of the coal-field of the lower coal-measures. The conglomerate extends farther. St. Clair County contains the very productive Belleville region, covering three-fourths of the county. The outcrop line runs from near Tamaroa to a point two miles south of Centreville, and it crosses the Belleville & St. Louis Railroad, two miles west of Centreville; thence it follows the river-bluffs to the Madison County line, just north of Caseyville; thence the line runs northward, including nearly the whole of Madison County, running to the Mississippi River, above Alton. The coal-beds underlie the eastern portion of Jersey County, north and east of the Jerseyville & Alton Railroad. Thin seams of coal are also found in the river-bluffs of Calhoun County. The prin-

cipal deposits of coal in Greene County are in the eastern portion, covering about one-third of its area. In Pike County, there is only one place where coal over two feet thick has been discovered. The coal-measures are in the central and northern parts of the county, and about 60 feet thick. More than half of Scott County, the eastern part, is covered by the coal-measures. The ancient valley of the Illinois River and its alluvial bottoms was much wider than at present, and, like the Ohio, it was excavated to a depth of more than 100 feet. In Brown County, the coal-measures were also cut away by denudation in the valley of the Illinois River and other streams, and are found under nearly all the uplands of the county.

About one-half of Adams County is underlaid by the coal-measures, embracing the central and eastern parts. Hancock County has only thin, local deposits of coal, and the supply is quite limited in detached outliers; but Schuyler, the county east of it, has the greater portion of its surface underlaid with coal. The supply of coal in Henderson County is quite limited, there being only one thin seam in one or two sections, but the coal-measures underlie nearly the whole of Warren, the next county east of Henderson. Mercer County has an abundant but unequally-distributed supply of coal; also, Rock Island and Henry Counties. Knox County is wholly underlaid with coal, there being but three townships in which coal is not now mined; and there is an abundant supply also in Stark County, and mines are opened at Buda, in Bureau County. Two-thirds of La Salle County are underlaid with coal, and three-fourths of Grundy, but only two townships of the southwest corner of Will County, coal is also confined to the extreme western portion of Kankakee, and the outcrop passes into Livingston County, near its northeast corner.

Here we come to the ancient deep river or ocean channel, which formerly run from Lake Michigan across the Illinois coal-field, and probably down the valley of the Illinois River. Passing over this, it is supposed that coal may be found in the southern part of Iroquois County, but of this nothing is yet known. The outcrop line here passes into Warren County, Indiana, from the southern part of Iroquois County. All the rock-formations of Vermilion County are of the coal-measures.

The Danville region in this county is quite productive, the coal-seam being about six feet thick.

Edgar County, farther south, also all belongs to the coal-formation, and all the numerous counties embraced within the boundaries described may be considered as underlaid by the coal-measures.

In a letter written in April, 1872, Prof. A. H. Worthen, the State geologist, gives his estimate of the productive coal-area of Illinois, founded on the most reliable data obtained in the prosecution of the geological survey of the State, at 36,800 square miles. The boundaries of the coal-field are shown on the annexed map, as accurately as can be done on so small a scale. It is all a prairie country, and very fertile.

Having thus defined the approximate boundaries of the great coal-field of this State, it will be proper next to examine its structure, its series of coal-seams, give a general view of its most productive districts, and to conclude with an account of the quality and quantity of coal produced in Illinois.

Structure.—The phenomenon of denudation which is so common elsewhere, and by which the upper portions of the coal-fields have been removed, is almost reversed in Illinois, where the lower coal-seams are restricted to the central and southern parts of the State, while the upper seams only extend to the northern confines of the coal-field, and are mainly to be relied on in that part of the State for a supply of coal.

This remarkable distribution of the coal-measures in this State results from a gradual sinking of the northern end of the Illinois coal-field during the coal-era; the southern end acting as the hinge, from which cause, each succeeding division of the coal-measures had a wider basin, and was extended in a northern direction so as to cover a larger area in that quarter than the one which had preceded it. The same thing is observed on the map of the Indiana part of this field. It also seems that, on the other hand, previous to the formation of the coal, from the beginning of the Devonian to the top of the sub-carboniferous limestone, this northern shore of the Pliocene ocean was gradually rising above the water-level, the southern end sinking or remaining stationary, so that the northern boundary of each succeeding group of rocks below the coal is farther south than

the preceding one, rock-making ceasing in the north, and continuing farther south. Hence, the coal-measures are found to rest on each of the lower formations from the St. Peter's, or Potsdam sandstone in the northern part, through the whole series up to the Chester limestone farther south, which was the true base of the coal-measures when all the series is complete. These oscillations are like two great vibrations of the pendulum of eternity.

Thus it happens that, while, in most other coal-regions, the lower coal-seams extend the farthest, in Illinois, on the contrary, they are the most limited; and the upper or later-formed seams extend past them farther north, and the bottom rocks below the coal become older successively as you proceed northward.

Thus, at the Colchester mines, in McDonough County, where a supply of coal is produced for the Quincy market, there should, according to the general section, be at least one or two beds below that which is here quite extensively mined. But this is not the case; the Colchester coal resting on the conglomerate on account of it being deposited in a basin, of which the bottom slopes upward and northward. Hence, it is not the lowest strata which abut against these borders, but, on the contrary, some of the highest seams extend farther, covering the margin of the lowest beds.

The same peculiar disposition has been remarked along the southern margins of the western coal-field of Kentucky, which is the southern part of this same great coal-region. In Christian County, and other places in that State, the fourth coal above the conglomerate abuts against the older formations, and the lowest coal has to be looked for farther back toward the centre of the basin.

Faults and Upheavals.—At Cobden, on the Illinois Central Railroad, 42 miles above Cairo, a mountain-ridge is observed, which crosses the State with an elevation of 500 to 600 feet above the level of the river at Cairo. This ridge is the eastward extension of an axis of elevation which brings the St. Peter's sandstone of the lower Silurian, above the surface, at Bailey's Landing on the west side of the Mississippi River, tilts up the Devonian limestone at the Bake Oven and Bald Bluff, in Jackson County, on the Big Middy, on the Illinois side, at an angle

of 25°, and after elevating the upper portion of the sub-carboniferous limestone above the surface, entirely across the southern portion of the State, finally crosses the Ohio in the vicinity of Shawneetown, in Gallatin County, Illinois; at the mouth of Saline River, it passes into Union County, Kentucky. Its extension eastward, through the western coal-field of Kentucky, is described in the account of that region. This mountain-ridge, running nearly east and west across the southern part of the State, has resulted from the dislocation and upheaval of the strata by forces acting from beneath, as is proved by the strata being dislocated and tilted at a high angle from their original horizontal condition, showing the effect of upheaving forces; leaving only sub-conglomerate coal south of this Shawnee fault or upheaval. There is another similar axis of disturbance or uplift, affecting the coal-field at its northern end, and the only one traversing the whole coal-field. It crosses the north line of the State, in Stephenson County, and intersects Rock River at Grand Detour, and the Illinois River, at Split Rock, between La Salle and Utica. Its general trend is from north-northwest to south-southeast, and it extends southeastward from La Salle across the State, to the Wabash River, in Wabash County. This uplift brings the St. Peter's sandstone to the surface on Rock River, and the lower magnesian limestone, or lower Silurian, on the Illinois, and it elevates the coal-measures to the surface in the vicinity of La Salle, from a depth of from 300 to 400 feet, thus showing that the disturbance took place at a period subsequent to the deposition of the coal-formation. The synclinal and essential axis of the coal-basin passes from La Salle in a direct line to Grayville, or to the southeast corner of Wabash County.

The absence of coal in some other localities is also connected with the other disturbances to be mentioned. There is a dislocation of the strata, and a downthrow of the beds on the south side of an axis in Calhoun County, which is situated between the Illinois River, near its mouth, and the Mississippi. The St. Peter's sandstone appears on one side of a ravine, and the Burlington limestone on the other, where there should be a thickness of more than 1,000 feet between them. This axis crosses the Illinois five or six miles from its mouth, into Jersey

County, and again crosses the Mississippi by the eastern bend, and is lost in the river valley, in Missouri. There is hence, probably, a deep indentation in the coal-field, extending above the mouth of the Illinois River.

Below St. Louis, we find another axis near the south line of St. Clair County, where the strata have been dislocated, leaving the St. Louis limestone, on the lower side of the axis, inclining to the southwest at an angle of about 20°. The trend of this axis is from north, 20° west, to south, 20° east, and it passes about half a mile east of the town of Columbia, in Monroe County.

At Salt-Lick Point, in Monroe County, is another dislocation, and downthrow of the strata.

Below the axis, in Jackson County, first mentioned, forming the Shawnee fault, there is another in Alexander County, the most southern county of the State, forming the Grand Chain, a dangerous reef of rocks, across the Mississippi River. But this is south of the coal-field.

Prof. A. H. Worthen thinks it probable that none of these disturbances date back to a period anterior to the carboniferous epoch; as he finds, in general, no want of conformity between the uplifted strata and any of the upper beds. He further says, if we could strip off from the surface of the State of Illinois the superficial deposits of sand, clay, and gravel, we should find it intersected by broad and deep valleys cut into the solid rock to a depth varying from 100 to 300 feet, and afterward filled by the superficial material called drift. Dr. J. W. Foster says these northwest and southeast flexures in the Illinois coal-field proceed from the Rocky Mountain system of upheavals, which are proved to have occurred later than the Triassic, and before the Cretaceous age, as the former are upheaved, and the latter are undisturbed.

Series of Coal-Seams.—According to the third volume of the State Geological Report of Illinois, published in 1868, which corrects the errors in the first two volumes, caused by following the erroneous sections in the West Kentucky survey, there are ten seams of coal in a vertical thickness of about 600 feet, six of them averaging 2½ to six feet in thickness, while the others range from two feet down to a few inches. They are

numbered consecutively from the base of the section upward, all the workable coals belong to the lower division of the measures, and are enclosed in the lower 300 feet of strata. There is no coal in the State, seen by Prof. Worthen, more than two feet in thickness, that appears to belong above the horizon of coal No. 6.

From the following description it appears there are about 500 feet of measures above the conglomerate, in Illinois. In the southern part of the State, where that formation is fully developed, and attains a thickness of 200 to 300 feet, some local developments of thin seams of coal, from two to three feet thick, occur in it, which are sometimes found to be valuable where the higher coals are not accessible. In the valley of the Illinois, however, the conglomerate seldom exceeds 25 feet in thickness, and is frequently wanting altogether.

These various seams of coal are separated by blue, red, gray, and brown shales, thin beds of limestone, sandstone, and sandy shales, separating each seam of coal from the next below, the general thickness of which is given as follows: From the surface 25 feet to No. 10, a bituminous shale and thin coal, then 77 feet to No. 9; 23½ to No. 8; 66 to No. 7; 73½ to No. 6—the first valuable seam, in all 265 feet; then 40 feet to No. 5, the most important seam of all; then 23 feet to No. 4; then from 80 to 100 feet to No. 3; then 75 feet more to No. 2, and 30 feet more to No. 1, below which occurs fire-clay resting on the millstone grit or the lower limestone, making in all 533 feet of measures down to No. 1, exclusive of the coal-seams.

Description of the Coal-Seams.

The lower, or *No.* 1 seam, ranges from two to three feet in thickness, and is of fair quality. In the northern part of the State it is of more uncertain development than some of the higher seams. It has an excellent roof of hard bituminous shale.

No. 2 varies in thickness from two to five feet, and the coal is of excellent quality. It is the lower seam at Murphysboro', the Colchester coal, in McDonough County, the Morris coal of Grundy County, the lowest seam at La Salle, the Braceville

coal, the lowest coal at the Pontiac shaft, the Neelysville coal, and the lower seam at Carbondale. It has a roof of clay-shale, and at some localities, as at Neelysville, a few inches of coal has to be left to strengthen the roof.

No. 3 is from three to four feet thick, and is somewhat local in its development, but it has been identified in two or three localities in Schuyler County.

No. 4 is a local coal, that has only been identified at Cuba, in Fulton County, and is 4½ feet thick.

No. 5 is one of the most reliable coals in the series, and is almost universally developed wherever the proper horizon has been examined. It produces coal of an excellent quality, and at some localities, as at Howlet's, in Sangamon County, the coal is remarkably free from sulphuret of iron, and from experiments recently made it seems to be pure enough to be used in the raw state for smelting iron. It is a harder and heavier coal than that from the seam above it, and appears to be by far the most valuable coal yet discovered in this portion of the State. It is the Howlet coal found in the shaft near Springfield, at a depth of from 230 to 250 feet below the surface; the Pleasant Plains coal; the Rushville and Pleasant View coal, in Schuyler County; the lower coal in the shaft at Petersburg, in Menard County; the lower coal at the old Pittsburg mines, in St. Clair County; the lower coal at Kingston, and on the Kickapoo, in Peoria County; the middle coal in the La Salle shaft, three to nine feet thick, usually six; the lower coal, one mile west of Brighton, in Jersey County, where it is three to four feet thick; and probably the Du Quoin coal, in Perry County.

No. 6 is the highest seam in the Illinois section that attains an average thickness of more than two feet in any part of Central or Northern Illinois hitherto examined. It is the Belleville and Caseyville coals, and the upper seam at the old Pittsburg mines, in St. Clair County; the Hodges coal, in Macoupin County; the upper seam one mile west of Brighton, in Jersey County; the upper coal at Kingston, and on the Kickapoo, in Peoria County; the upper seam at Petersburg, and the three feet seam in Beard & Sanderson's shaft, near Springfield; the upper coal at La Salle, and the Sparta coal, in Randolph County; and most probably the coal reached in the

shaft at Carlinsville, at the depth of 275 feet. In the southern part of the State it is generally from six to seven feet in thickness; in Peoria, Fulton, and La Salle, from four to five feet; while in Sangamon and Menard its thickness varies from a few inches to three feet: the coal afforded by this seam is generally softer and lighter than that from No. 5, and the seam is more uncertain and irregular in its development, and consequently more expensive to mine, from the frequent occurrence of "horsebacks." Prof. Worthen says he has never seen both these coals, Nos. 5 and 6, developed at the same locality to their maximum thickness; but, where one attains a thickness of six or seven feet, the others will be quite thin, or perhaps entirely wanting. This is the case in St. Clair County, where No. 6 is fully developed, and No. 5 is too thin to be worked profitably; while in Sangamon and Menard Counties the lower seam averages about six feet in thickness, while the upper varies from a few inches to three feet. In Peoria and Fulton Counties they both attain a workable thickness ranging from four to five feet, but do not reach the maximum attained at points farther south.

Above coal No. 6, we find a series of sandstones and shales, alternating with thin beds of limestone, with five or more thin seams of coal ranging from a few inches to two feet in thickness. These upper seams have not been found thick enough in Northern Illinois to be of practical value in the production of coal.

There is, perhaps, no other area of equal extent in the United States where coal is so easily obtained with a moderate expenditure of capital as in the Illinois coal-field. This results in part from the undisturbed condition of the strata, and from the position that the principal seams occupy near the middle of the measures, rendering them accessible by shafts almost everywhere in the central portion of the State, at a depth ranging from 200 to 400 feet. The dip of the coal from the western border of the State to Springfield is to the eastward, about seven feet to the mile. On the eastern border of the State no detailed examinations have as yet been made; but it is not probable that the western dip of the strata will be found to be much greater than that in the opposite direction. Hence, the mining engineer will be able to estimate with considerable

accuracy at what depth coal may be reached at any point in the centre of the coal-field, from a knowledge of the surface-level and the general dip of the strata, and to calculate the amount required to put a coal-mine in successful operation at a given point.

Productive Coal-Districts.

The four fine volumes now issued, of the Illinois Geological Report, contain many valuable details of the coal-formation in various counties of the State, as developed by the many mines opened and shafts sunk. But, as it is here proposed to give a general account only, these particulars cannot be given in full. The more productive portions of this great coal-field, however, require a further notice; and these districts are found where the previous description of the structure of the field would lead us to expect them. We will first enumerate and then describe them; beginning at the south, and, as they occur in going northward, around the west side.

The Shawnee fault, or upheaval, bringing the lower coal-measures containing the large workable seams near the surface, makes the coal accessible in the southern part of the State. Nothing better need be asked than seams of good coal six or seven feet thick, accessible by shafts from 50 to 75 feet deep; only 76 miles by railroad, from the junction of the Ohio and Mississippi River, at Cairo. This is the Du Quoin district, in Perry County.

The Big Muddy iron-[illegible]ing block-coal, of Jackson County, would be valuable anywhere without the other advantages which it possesses, of its vicinity to the Mississippi River, to St. Louis, and especially to the great iron-ore deposits of Missouri.

The third productive district is the Belleville, a little farther north, with only from eight to 14 miles of railroad transportation to St. Louis, with a seam of coal generally seven feet thick, with an excellent roof, good facilities for mining, and the city of St. Louis to supply. Farther north we have the Quincy, Springfield, Danville, La Salle, and Wilmington districts; the last two supplying the Chicago market.

The conglomerate or millstone grit, in Jackson County, in

Southwestern Illinois, consists of quartzose sandstone mostly, nearly white, but sometimes colored by ferruginous matter, and frequently contains rounded pebbles of quartz-rock, from the size of a pea to those three or four inches in diameter. When ferruginous, it weathers very unevenly, and leaves a hard, brown crust upon its surface, formed of sand, cemented by the brown oxide of iron. Where the quartz-pebbles are abundant, the finer materials disintegrate from around them, on the exposed surface, and leave them projecting from the perpendicular walls of sandstone like partly-embedded cannon-balls. Locally, it passes into shales, or thin-bedded limestones, and it contains thin beds of argillaceous shales. The sandstones are sometimes soft, and decompose readily on exposure, and such outcrops form towering cliffs and bold escarpments in agreeable contrast to the usual monotony of the more level landscapes.

The thinning out of the Illinois conglomerate in a northern and northeastern direction into a thin plate in Indiana, entirely free from pebbles, would seem to prove a southwestern origin for its materials, unlike that of Pennsylvania, which thins out from southeast to northwest, and indicates the age of the Cincinnati anticlinal barrier to be before the Carboniferous period. The conglomerate sandstones, at the base of the true coal-measures, are included in the general title of coal-measures in Illinois. In the southern part of the State, south of Randolph County, they are 200 to 300 feet thick, and at some points contain well-defined coal-seams, though they are generally local in their character. This sub-conglomerate coal recalls to our mind that, in a similar position, on the west side of the eastern Kentucky coal-field, and in Tennessee, as well as that of Arkansas.

The Illinois conglomerate thins out as we proceed northward, and in the valley of the Illinois River it is only 25 feet thick. In every instance, coal appears to be found in the conglomerate, on one side or end of the field more than on the other, or in localities protected from currents or other accidents, or favorable to the preservation of its materials. After a great number of facts shall have been collected on this and similar subjects, they can be compared, placed side by side, and any modifying conditions observed. Thus, in time, a law or prin-

ciple governing them may be seen to guide us in understanding what at first may seem fortuitous, and these laws, or great classifications of accurate observations, constitute a science.

Coal has been found also in the Chester group, in Johnson and Pope Counties, as much as six inches thick, but it has only a scientific interest. The conglomerate coal, in Johnson County, is reported at from one to two feet thick in six localities, and in a few other places it is found four or five feet thick, the increase being due to an admixture of shales which impairs the quality of the coal. The important Big Muddy iron-smelting coal is above the conglomerate. The lower coal-measures, including a thickness of 250, or possibly 300 feet of strata, consisting of sandstones and shales, and some thin beds of limestone, have within them three or four seams of coal. The lowest persistent seam in this series is the one outcropping just at the top of the conglomerate, and is usually from 16 to 24 inches in thickness. It is a fair quality of coal, but too thin to work with profit.

The Big Muddy Region.

The next coal-seams in the series of a workable thickness are the Murphysboro' coals, which are well exposed, near that town, on the Big Muddy River, where the section consists of 20 feet of micaceous sandstone, then the upper three feet seam of coal, 27 feet below which, or 50 feet from the surface, occur the two seams, three feet and two feet, separated by from two to eight inches of clay-parting. This lower, or rather two lower seams, affords an excellent quality of block-coal, sufficiently hard to bear the pressure of a charge in a blast-furnace, and sufficiently free from sulphur to be used in a raw state for the smelting of iron. This quality greatly enhances its value, from its proximity to the St. Louis market, as well as that of the great West, and to the immense iron-ore deposits of the Iron Mountain, in Missouri.

Jackson County has about one-half of its area underlaid with coal, the outcrop-line running from the southeastern to the northwestern corners of the county. There are at least three, and perhaps four seams outcropping in the county, rang-

ing in thickness from a few inches to six feet. In the northern part of the county the coal is from four to six feet thick.

The mines at Murphysboro' and Carbondale, in that county, on the Illinois Central Railroad, produce an excellent coal—for this country, one of the best known in the State of Illinois—having been successfully used in its raw state for smelting-iron. A railroad has been built by the Mount Carbon Coal Company to the Mississippi River, 15 miles in length. At Murphysboro' three seams are developed, the two lower ones being so near together that they can be worked as one seam, being separated by a parting of clay-shale, from a few inches to two feet in thickness; the upper seam averaging three feet in thickness, and the lower one about two feet. The coal from both divisions is good, though that from the lower appears to be more free from sulphuret of iron. The coal is hard and bright, and the layers separated by carbonaceous clod, or mineral charcoal. Its analysis gives: moisture, 6.5; volatile matter, 31.2; carbon in coke, 60.8; and ashes, 1.5. Prof. Worthen seems to think this coal is a local development of limited extent, as the next outcrop, in a northern direction, reveals only a thin seam of coal from six to 12 inches thick. Jackson County produced 166,800 tons in 1870.

At Carbondale, the lower division of the main Murphysboro' seam is not found at all, and the upper division is about four feet thick, while the upper seam, 35 feet above the lower, is three feet in thickness. The clay-parting which divides the lower seam at Murphysboro' increases in a southerly direction so rapidly, that a mile distant, in that direction, the divisions are too widely separated to be worked as a single seam.

There is one seam below those of Murphysboro' and Carbondale, usually at the top of the conglomerate. Its character is variable; at some localities it affords a coal of excellent quality, and at others it is quite poor, and mixed with slate and sulphuret of iron. It is from three to 30 inches thick, and it is doubtful if it extends to the northern part of the county. The position of the Big Muddy and Carbondale coals in the series is important to be observed, and its situation with reference to the other block-coal regions of Clay County, Indiana, Massillon, Stark County, Youngstown, in Trumbull County, Ohio, and

Sharpsburg, Mercer County, Pennsylvania, all producing the same iron-smelting block-coal, is worthy of special notice. The Big Muddy coal, however, is by no means equal in quality, as an iron-making coal, to those of Indiana, Ohio, and Pennsylvania. Its character as block-coal is not fully established.

The Mount Carbon coal-mines, on the margin of the Big Muddy River, near Brownsville, Jackson County, Illinois, a short distance from its junction with the Mississippi River, were noticed in the *Journal of the Franklin Institute*, as long ago as 1836, and are stated to have then been worked on a limited scale for many years previously, having been opened in 1810.

Du Quoin Region.

The mines at Du Quoin, in Perry County, 76 miles north of Cairo, on the Illinois Central Railroad, produced 22,539 tons in 1868, and 30,250 tons in 1870, transported on that railroad. The seam of coal—probably No. 5, and sometimes stated as No. 6 in the scale already given—measures six feet in two shafts, and six feet four inches, six feet six, and six feet seven inches in three others—the shafts being 48 feet, 56 feet, 57 feet, 60 feet, and 75 feet deep respectively, to the top of the coal.

It will be noticed that in this southern part of Perry County there is a fine thickness of coal, and so near the surface that it can be worked very economically. The two seams, Nos. 5 and 6, are the two thickest and most persistent in the State, except perhaps No. 2. In the central portion of the State where the upper or Barren Measures are well developed, and where there is no extraordinary accumulation of drift-material above the coal-measures, this No. 5 is usually found at a depth of from 200 to 300 feet, which depth gradually diminishes as we approach the borders of the coal-field. In the southern part of Perry County it is usually found from 40 to 80 feet below the surface, and dips slightly to the northward, so that at the north-east extremity of the county it is from 200 to 250 feet below the surface-level.

The Du Quoin coal is of excellent quality, above the average of Western bituminous coal; and, although at some points it contains considerable sulphur, this occurs in nodules or lenticular masses, and can be readily separated from the coal in the

process of mining. The coal averages fully six feet in thickness in Perry County, and has a hard, somewhat bituminous clay-shale roof, which admits of taking out the entire thickness of coal, instead of leaving a portion to sustain the roof, as is usually done when the roof consists of soft material. At Pinckneyville and other places the coal is directly overlaid by a hard blue limestone, that forms a still better roof than the bituminous shale. The analysis of Du Quoin coal showed: moisture, 8.5; carbon in coke, 48.1; volatile matter, 40.4; ashes, 3.00; carbon in coal, 59.6.

The Du Quoin coal-seam is subject to some irregularities, such as "clay-slips," or "horsebacks," sometimes called faults by the miners, which consist in a thickening of the roof-shales, thus cutting off or pinching the coal-seam to one-half or three-fourths of its usual thickness. These irregularities may have resulted from a partial removal by water-currents of the vegetable matter which formed the coal, and its replacement by a fine, muddy sediment at a subsequent period. They are not faults in the sense in which that term is generally used in mining, which signifies a dislocation or displacement of the strata, so as to prevent its continuity on the original plane of deposit, for in this case there is no dislocation, but only a replacement of a part of the coal by the same material that forms the roof.

At St. John's, near Du Quoin, there were 13,860 tons of coal mined in 1868, and 27,690 in 1870, and shipped by the Illinois Central Railroad. No account is taken, in any of the statements here given, of the coal not shipped to market by railroad.

At Tamaroa, nine miles north of Du Quoin, in Perry County, there were 17,070 tons mined and shipped in 1868, and 14,400 tons in 1870, and at Du Bois, 8,760 tons in 1870. By the United States census of 1870, the production of coal in Perry County was 195,400 tons.

The whole of Perry County is underlaid by this coal, affording a vast abundance of it, with great facilities for mining, from its proximity to the surface, and other favorable conditions.

The peculiar importance of the advantages stated in regard to Perry County is the more apparent when we observe that the Barren or upper coal-measures, which occur in Washington, the county immediately north of Perry, are wholly destitute of coal,

and the lower coal-measures lie at such a depth that at present there is no very productive coal-region between Tamaroa and Chicago, on the Illinois Central Railroad, nor any on the Galena branch, until we get to La Salle.

Belleville District.

St. Louis obtains its principal supply of bituminous coal from the Belleville district, in St. Clair County, Illinois. It is brought to East St. Louis by a branch of the St. Louis, Alton & Terre Haute Railroad. This railroad is only 14 miles long from East St. Louis to Belleville, but it intersects the western boundary of the coal-measures at Centreville, six miles out from East St. Louis, and runs eight miles through the coal-field. St. Clair County contains 450 square miles of coal, or three-fourths of the county, embracing all the central and eastern portion, with a thickness of about 300 feet of the lower and most productive part of the coal-measures, embracing five coal-seams, only two of which, however, appear to be of economical value at this time.

In 1871 there were transported by this railroad, from Belleville and Centreville to East St. Louis, 361,630 tons. The last United States census reports the coal production of St. Clair County at 798,810 tons. This is, therefore, by far the most productive, and in that respect the most important coal-region in Illinois.

The thickest coal-seam outcrops in the river-bluff, and along the western borders of the coal-measures in the southwest portion of the county. The dip is very moderate, not more than five or six feet to the mile, and is in an easterly direction, or a little north of east, and in consequence the coal lies deepest below the surface in the eastern portion of the county.

The Belleville coal-seam, No. 6, is the principal one worked, and it was probably the first ever worked in the State. Its natural outcrop along the bluffs, in such close proximity to St. Louis, called attention to its value at an early day. Its general thickness in this county ranges from five to seven feet, and it has a substantial limestone roof, so that it can be worked with safety, and in the most economical manner.

This coal is generally quite regularly stratified, and the two upper layers, which vary in their aggregate thickness from 16 to 24 inches, are much the purest in quality. It is usually separated from the lower coal, and is sold at about two cents per bushel higher, as a blacksmith-coal. The lower coal contains more sulphuret of iron, but the quality varies somewhat in different mines, and no general description would be applicable to every locality. Sometimes there is a foot or more of bituminous shale above, and a thin bed of clay-shale below; but sometimes both are absent, and it is by no means uncommon, either in this or the adjoining counties, to find the coal directly enclosed between two beds of limestone of marine origin, containing fossil-shells in abundance, which is a very unusual occurrence elsewhere.

The main coal-seam, No. 6, in the section, has been opened at many points about Belleville, where it approaches near the surface in the ravines, and on the main creek, and was at first worked by drifts into the bank of the creek along its outcrop. On the railroad between Belleville and the river-bluffs it is reached by 25 shafts sunk to the depth of from 50 to 150 feet. In Alma shaft the coal was found at a depth of 170 feet below the surface, and the seam is seven feet thick. It is the same thickness at Mascoutah at 132 feet deep, and 6½ feet thick at Urbana, and about the same depth below the surface.

In the southern part of the county the Belleville coal is opened at many places along its outcrop, and retains its full thickness of about seven feet. Everywhere it seems to be from six to seven feet thick.

The next seam below the Belleville coal, No. 5, has only been opened at a single locality, which is at the old Pittsburg mines at the river-bluffs, about one mile north of Centreville station, on the Belleville & East St. Louis Railroad, and is here about three feet thick.

It will be seen that the coal-measures underlie nearly all the highlands in the county of St. Clair, except only a narrow belt from three to five miles wide across the southwest border, and the land is also among the most productive agricultural lands in Southern Illinois.

The analysis of the Belleville coal shows the following results:

	Specific Gravity.	Loss in Coking.	Weight of Coke.	Moisture.	Volatile Matter.	Carbon in Coke.	Ash.	Carbon in Coal.
Caseyville Mines......	1.304	39.8	60.2	6.0	33.8	55.2	5.0	55.8
Pfeifer's Mines........	1.293	44.3	55.7	8.5	35.8	51.2	4.5	57.5
Belleville Mines.......	1.293	45.0	55.0	5.5	39.5	49.6	5.4	54.6
Dill & Knapp's Mines.	1.340	42.51	57.49	4.43	38.8	44.48	13.01	54.28
Churchill Mines......	1.315	45.40	54.60	6.00	39.40	45.70	8.90	52.63
Belshas..............	1.296	44.66	56.34	8.10	35.56	47.74	8.60	54.50

Prof. Worthen says that, from this analysis, the Belleville coal will compare favorably with the average of bituminous coals from other localities, either of this or the adjoining States.

Neelysville, Danville, and other Districts.

Proceeding farther north from the St. Louis district, we find most of the coal is at present mined around the western borders of the coal-field, that being most accessible, and nearest to the points where coal is in demand.

The outcrop of the field runs through Madison County, where are the Edwardsville mines; then northward through Jersey County, where there are three or more seams of workable thickness; then Greene County, which has one-third of its area covered by the coal-measures. Seam No. 6 here varies from four to six feet in thickness, while north of this No. 5 attains an average thickness of six feet. Next comes Scott County, with more than half of its eastern portion underlaid with coal, the valley of the Illinois River, on the west side of this county, having no coal.

But here occurs one of the great east and west railroads, the Toledo, Wabash & Western, whose western termini are at St. Louis, Quincy, Keokuk, etc. Some of its more important mines are at Neelysville, in Scott County, 15 miles west of Jacksonville, and 37 miles east of Quincy, where 21,217 tons were shipped in 1868.

In the vicinity of Springfield, deeper shafts have been sunk in the interior of the coal-field, where, as before described, the upper or Barren Measures cover the productive seams of coal to a greater depth. Here they are drawing upon the vast store of mineral fuel which was placed in reserve for the distant future. Howlet's mines, seven miles east of Springfield, produced 10,171 tons in 1868, carried by the Toledo, Wabash & Western Railroad, and smaller quantities were produced at other places in the same vicinity.

But a more productive district is that of Danville, on the same railroad, in Vermilion County on the eastern State line adjoining Indiana. Vermilion County produced 115,640 tons of coal in 1870, mined principally at Danville and Catlin, six miles farther west.

The coal of the main Danville seam is a strong, fat, soft caking-coal, averages six feet thick, lies nearly level, dipping, say 10 feet per mile toward the southwest. It is hardest and most impure in its lowest stratum of eight inches, purest and best in the blacksmith's-coal stratum, one and a half to two feet above, and more and more friable as you near the roof. The seam contains sulphur, but it is in masses easily separated and thrown out, and therefore less of a detriment in use than would be a smaller portion more intimately associated with the body of the coal. The roof is generally not good in the workings so far explored. The main defect of the Danville coal is its friability and tendency to slack on exposure. It is a strong steam-coal, and answers a very good purpose for all domestic uses.

Quincy is supplied with coal principally from the mines at Colchester, 53 miles farther north, on the Chicago, Burlington & Quincy Railroad, in McDonough County, where 47,491 tons were shipped in 1868, on that railroad, and 60,750 in 1870; and Rock Island County produced 127,630 tons.

Omitting some smaller mines producing each 3,000 to 4,000 tons in 1868, we come next to the Kewanee mines in the northwest corner of Stark County, 31 miles northeast of Galesburg, which produced 42,570 tons in 1868, for transportation of the Chicago, Burlington & Quincy Railroad.

At Buda, in Bureau County, and other points along the outcrop or borders of the coal-field, other mines are opened.

La Salle District.—(From H. C. Freeman's Report.)

The northern border of the Illinois coal-field, on account of its vicinity to the great market afforded by the city of Chicago, is for obvious reasons destined to be one of the most productive districts in the State. The great geological feature of La Salle County is the anticlinal axis before described, extending diagonally across it north 33° west, and passing in a southeast direction across the whole Illinois coal-field to the Wabash River, in

Wabash County. In La Salle County it exposes the calciferous division of the Potsdam, which is the oldest formation that has been seen in the State, and this county being the only one where it has been found. East of the axis the lower coal-measures only are found, and they rest on the St. Peter's sandstone, and here only one workable bed appears, being the lower one, and the coal-measures on this west side are inclined at an angle of only one or two degrees; and a couple of miles east of the axis the formations are level or very nearly so, with a gentle dip to the southeast.

West of the axis both the upper and lower coal-measures are found nearly coextensive with a maximum thickness of over 500 feet, resting on the Trenton or St. Peter's. West of the axis, north of the Illinois River, and west of the Vermilion River, which is on the south side of the former, there appear to be three continuous workable beds of coal, locally known as the Upper, Middle, and Lower, and a fourth workable bed appears on the south part of the county. West of the axis the coal-measures are inclined at an angle of about ten degrees on the Trenton, at the outcrop.

The thickness of the upper seam, No. 6, of the general section, is 4½ to 5 feet; that of the middle coal, No. 5, is from 3 to 9 feet, usually 6 feet; and that of the lower, or No. 2, is 4 feet. The latter has been traced to the vicinity of Morris, in Grundy County, and is the equivalent of the fine coal at Murphysboro', in Jackson County.

The following table shows the depth of the shafts to the top of each coal, the differences from the surface being caused by the different points of elevation where they are located:

COMPANIES.	DATE COMP'Y BEGAN.	Upper Coal.	Middle Coal.	Lower Coal.	Upper to Middle.	Middle to Lower.	Upper to Lower.
La Salle Coal Mining Co..........	1856	198	260		62		
Northern Illinois C. & I. Co......	1856	175	232	395	57	163	220
Peru Coal Mining Co............	1856	94		354			260
Chicago Coal Co.................	1865	174	221		47		
Illinois Valley Coal Co............	1865	224	294	433	70	39	209
Kenosha Coal Co.................	1865	229	283	402	54	19	173

They are all in the same township with La Salle and Peru, the Illinois townships being 36 square miles.

In 1868, the Illinois Central Railroad carried 77,370 tons

of coal from La Salle, and 46,200 tons in 1870; and 33,140 from Wenona, 20 miles south of it, and smaller quantities from other mines, making in all 111,630 tons from the La Salle district. The statistics of the quantity mined in each county in Illinois are given in the Appendix. La Salle County produced 173,864 tons in 1869–'70.

The La Salle upper bed, No. 6, is quite regular, varying from 4½ to five feet in thickness. The lower bed is also quite regular. The middle bed, or No. 5, has a peculiarity not found in either of the others. It has a tendency to a lensiform arrangement, caused by resting upon an uneven bed. The covering also is uneven, apparently from the action of currents leveling down the strata over the coal, and sometimes part of the coal itself. This feature has given rise to its less frequent appearance than the other beds in the outcrop, and its greater thickness, which is sometimes eight or nine feet. In the Streator district, in La Salle County, the coal-bed is nine feet thick.

Of the coals mined at La Salle and vicinity, the most popular in the market is the middle bed. The upper bed is a lighter coal, dry, free-burning, with an open fire, and is a good steam-coal, but consumes more rapidly than either of the others. It is harder to mine than either of the middle coals, and has some pyritous bands running through it near the top, which produce inferior coal. The mining of this upper bed was almost suspended at the date of Mr. Freeman's report.

The middle bed, from which the chief supply is derived, makes a denser fire; it is also a good steam-coal, largely used by the Illinois Central and Northwestern Railroads for locomotives; is the popular coal for domestic use, and is also used in blacksmithing, by selecting it. It is mostly mined with powder, without undermining with the pick. In burning, it lasts longer than the upper bed in an ordinary fire, and it is preferred to the lower coal by glass companies. It is a tolerably pure coal, having but little pyrites, and that in stratified bands, easily removed in mining. It often carries a band of cannel-coal on top, from three to 18 inches in thickness, which is of sufficiently good quality to be marketed with the rest.

The lower coal is the most highly bituminous of any of the

beds; cakes in burning, and throws off a dense, flaky soot, like Pittsburg coal; lasts longer in burning, and appears to be a stronger heating-coal, if properly burned, than either of the others. It is an excellent coal, but has one drawback in having pyrites disseminated in very thin scales in the vertical seams, which cannot be removed in mining, but, if carefully selected, is an exeellent blacksmith-coal, and its current price in the market is fifty cents per ton more than the middle bed. It is thought, if properly managed, it would make an excellent coke for iron-furnaces.

The railroad and water communication gives La Salle peculiar advantages which must eventually give this point the controlling influence in the coal-trade of Northern Illinois, and the abundance of coal, of qualities suited to different wants, must, at the same time, tend to build up a great manufacturing city here.

The Wilmington District.

The La Salle district, before described, is said to be the only locality in the State where the coal-measures appear to have been disturbed after their deposition. Here they were elevated as much as 400 feet by the uplift which has already been fully described.

But the limestones on which the coal-measures rest presented an uneven surface for the reception of the coal-bearing strata, which was caused rather by denuding influences which had worn the surface into shallow troughs or valleys, than by upheavals and dislocations of the strata. On the extreme north-eastern border of the coal-field, in Grundy, Will, and Livingston Counties, the measures contain a single seam of coal averaging about three feet in thickness, which is overlaid by a heavy bed of clay-shale or soapstone, that passes upward into a sandy shale or sandstone. In the vicinity of Morris, the seam is about 30 feet below the surface, and averages about 30 inches in thickness.

Along the line of the Chicago & Alton Railroad, from Wilmington southward for 13 miles or more, this seam has been reached at many points, and its proximity to Chicago renders this locality a very important one to the coal interests of that

city. Although the coal-seam averages considerably less in thickness than those wrought at La Salle and some other points in the northern portion of the State, yet its proximity to Chicago, from 53 to 65 miles, and it being the nearest point to that city where available coal can be found on any direct line of railroad communication, the ease and cheapness with which it can be reached by shafts varying in depth from 30 to 200 feet, and the superior quality of coal it affords, render this a very valuable and important deposit.

Although it is called "Wilmington coal," in Chicago, where large quantities are sold for steam and domestic purposes, yet no coal is found at that place, or at any point north of the Kankakee River. At Braidwood a large amount is mined annually. The mines have both a bad roof and floor, yet all the coal in the ground is mined out by the long-wall system of mining. Gangways are run from the bottom of the shafts in a radiating manner; the masses of fragile fire-clay shale, or soapstone, as it is called, which fall from the roof, are built into a rude wall at each side of the roads. When the floor becomes wet, the soft fire-clay floor rises in the gangways. This material is also disposed of in the gob, and the roof is suffered to rest upon it. The mining is thus all done in a constantly-enlarging circle, a good ventilation passing around the face of the work, and no coal is left in the rear of the miners, except blocks immediately around the bottom of the shaft to secure its permanency. The coal contains much less sulphur than some other Western coals, but a large amount of moisture, which in the mines stands in drops on the face of the work. The coal is taken to Chicago, and carted off for immediate use. Although its heating power is less than in the same weight of Eastern coals, it makes a good steam-coal, and is invaluable as a locomotive-fuel in this treeless country. Will County produced 228,000 tons in 1870.

Farther south, difficulties are met with in sinking shafts for coal-mining purposes. In one at Bloomington, 200 feet of blue clay and drift material were first passed through. At 285 feet, a seam of coal three feet eight inches in thickness was met with; at 400 feet, four feet six inches of coal; and, at 530 feet, three feet of coal. In passing southward from the Wilmington district, we unexpectedly come to a region that is practically

almost destitute of coal. It seems, from the report of Prof. F. H. Bradley on the counties in this part of the State, that at some former period some powerful denuding current has torn up the rocks, and excavated a broad, deep channel, extending from the southern end of Lake Michigan, down the eastern line of the State, until, shortly after passing the line now occupied by the Kankakee River, it rose over the Niagara limestone, and bore off southwestward through the softer beds of the coal-measures which here lie directly upon the Niagara. This channel passes through the central and western parts of Iroquois County, and includes large parts of Ford, Champaign, and McLean Counties, with the southeastern part of Livingston, where no rock is struck until you reach the green calcareous shales of the Cincinnati group, at 200 feet. To the westward of Champaign County its course is not so well indicated; we only know that it runs under Bloomington, in McLean County, with a depth of 254 feet, and Prof. F. H. Bradley inclines to believe that this point is near the centre of the old valley. He further suggests that its junction with the valley of the Illinois will probably be found somewhere in Tazewell or in Mason County.

The erosion of this great valley, of course, took place before the beginning of the Drift period, since the deposits of that period not only fill it completely, but deeply cover its banks. Two difficulties are presented by this peculiar formation: first, is the entire absence of coal, probably, in this ancient valley; and the other is, in case of the existence of coal, the great difficulty in sinking shafts to such depth as may be necessary, not only through drift, but through a heavy bed of quicksand, that is said to rest directly upon the rock, which presents a serious obstacle to the sinking of shafts.

In the description of the outcrop-line of the coal-field are found no traces of coal east of the corner of Kankakee and Livingston Counties, or south of that point, till we come to Vermilion County; so far as known, there is no outcrop of rocks in either Ford or Champaign County. A shaft was sunk at Champaign, 179 feet through loose material into quicksand, which defied all efforts to reach a greater depth. The examinations made in McLean, Tazewell, Logan, and Mason Coun-

ties, show a depth of drift of about 250 feet, as at the shaft at Bloomington. It seems probable that this may be the depth over considerable portions of McLean County, and near the edges of what is supposed to have been the ancient river, as, in the west part of Tazewell, and the east part of Logan Counties, it is not less than 50 feet. Where the rock has been reached, in the shafts sunk, the coal-measures are found, apparently the middle portion of the formation, the coal-seams being three or four feet thick.

Quality of Illinois Coal.

Sulphuret of iron is almost the only mineral found constantly associated with coal, and this is more or less abundant in all the beds; some possess it in large quantities, a thin stratum often running for a considerable distance in the centre of the deposit. It also appears in thin veins between the seams of the coal, as, for example, occupying only the thickness of the fossil leaf which is replaced by the sulphuret, and bearing on its surface the ribs and nervures in beautiful relief. Sometimes it is found between the laminæ of coal in filaments and dendritic fibres, spreading out like the branches of a tree, and with various colors resembling fine brass, gold, and silver.

Iron, in the form of a sulphuret, is almost universally distributed through the Illinois coal, either as crystals or as nodules, often of many pounds' weight. This mineral is utterly worthless for all purposes except for the manufacture of vitriol (sulphuric acid) and copperas (sulphate of iron), and its general dissemination through a coal-seam renders the coal itself almost valueless. It is the great bane of our Western coals, rendering them often almost useless for working iron, until the sulphur is expelled by coking, which is sometimes rather difficult to do successfully. When this sulphuret occurs in balls or masses of any considerable size, it should be carefully separated from the coal at the mouth of the shaft, or in the adit; but when it is disseminated through the coal in thin scales, or in minute crystals, it can only be expelled by the process of coking. Many coals are made to retain a fair reputation by being carefully freed from this material before the coal is sent to market. Sometimes it is confined to a particular portion of the seam, and,

when this is the case, the portion containing the pyrites should be mined and sold by itself, or, if worthless, thrown aside. It is usually of a bright-yellow or silver-white color, effloresces on exposure to the atmosphere, generating thereby heat that sometimes results in spontaneous combustion, and ignites the bituminous shales, or the coals themselves. There is also another substance found in our coals, traversing the layers in thin plates, of a white or glassy transparency. This is lime, either in the form of a carbonate or sulphate, most frequently the former, and does not affect injuriously the quality of the coal.

Dr. Blaney, in the chemical report for the same survey, says: "Many coals contain much lime, combined with sulphuric acid, to form gypsum, filling the natural joints; and if the coal, at the same time, contains much pyrites or bisulphuret of iron, which during combustion loses its sulphur and peroxide of iron, the materials from which to form clinker are furnished. It requires a high temperature to fuse these ingredients into a slag, and hence many coals which form no clinker in open grates, and are highly esteemed for domestic purposes, are totally useless in the high temperatures of the reverberatory furnace for remelting iron, or even for locomotive use."

In his table of analysis of Illinois coals, Dr. Blaney gives the quantity of moisture they contain, and says: "By this is meant the weight per cent. of water which is retained mechanically by the coal, and which is given off at a temperature of 250° Fahr., a temperature at which no decomposition of the volatile combustible matters takes place. In the analysis reported in most of the works of authority on coals, this moisture is not separately determined, but is included in the estimation of the volatile combustible matters. This detracts much from the value of the analysis, for the hygrometric moisture not only is of no value as combustible matter, but absolutely diminishes the effective value of the fuel. There is a great difference in the capacity of different coals to retain moisture even after long seasoning, and its retention to any large amount must be considered as a detraction from the merits of the coal. There can be no doubt but that the presence of water in any coal also diminishes, to a great extent, the amount of illuminating gas which it would otherwise produce."

The effect of this moisture in the coal will be given more at length hereafter, in the chapter on the combustion of coal. But it may be here briefly stated that, according to Dr. Blaney, the heating power of coal depends on the amount of oxygen with which it will combine, and one pound of carbon combines with $2\frac{66}{100}$ pounds of oxygen, and a pound of hydrogen with eight pounds of oxygen. We must, therefore, multiply the percentage of carbon by $2\frac{2}{3}$, and of hydrogen by 8, and deduct the oxygen already combined in the coal. But the water in the coal must be converted into steam, and one pound of oxygen consumed will convert above $5\frac{22}{100}$ pounds of water at the boiling-point into steam; therefore, divide the percentage of water by $5\frac{22}{100}$, and deduct the product also.

Colonel J. W. Foster, a distinguished geologist, of Chicago, says: "The coals of Northern Illinois are, ordinarily, highly charged with water, often containing as high as 12 per cent., and are so sulphurous as to disintegrate on exposure to the atmosphere. Still, they are extensively mined for domestic fuel, and for generating steam in stationary engines and locomotives."

These unfavorable features in regard to the Illinois coal are given in the language of her own geologists; for it is indeed but too evident that, as compared with the coal produced in almost any part of the Alleghany coal-field, that of Illinois is very inferior. Its disadvantages are its feeble heating power, the extraordinary quantity of sulphuret of iron it contains, and the large amount of clinker, ashes, soot, and smoke produced. Its impurities render it necessary that it should be used very soon after it is mined, as in a few days it falls to pieces; being very friable, it does not bear transportation, and no considerable quantity of it can be kept together, as it is liable to spontaneous combustion.

The valuable features of the Illinois coal are, that there is plenty of it; that it is very widely distributed over the State, and accessible. For, although it is necessary to mine it by means of shafts in almost all cases, yet the coal is reached at a reasonable depth from the surface; its mining is done without unusual expense; the great number of railroads in all parts of this prairie State, with good level grades, and without curves,

furnish an abundance of cheap transportation; and, poor as the coal is, there is a large market for it, for the want of better. In Chicago, as is shown in the table in the Appendix, a large quantity of Pennsylvania anthracite is sold, owing to the very cheap transportation from Buffalo by the lakes, the usual freight, previous to the present year, being from 50 to 75 cents per ton. A large amount of Erie and Cleveland block-coal is also sold there for grates and steam; also, they have Blossburg coal for blacksmithing, and the best gas-coal from the Pittsburg region; there being, in fact, a stock of every variety of the best coals produced in the United States for all the various uses.

Nothing is too good for our Western people, cost what it may; and then, the poor man's coal is their own Illinois bituminous, which is brought by rail from the northern limits of their coal-field, about 60 miles south of Chicago, and sold, uncleansed of sulphur and slate, in considerable quantities to those who cannot afford the better qualities of Pennsylvania coal. Large quantities of the Pennsylvania and Ohio coals are shipped from Chicago by rail, in all directions, as far west as Omaha, and far south into the interior of Illinois. In localities too remote to obtain these, their own coal is extensively mined, and used for domestic purposes. More care in mining and cleaning would very much improve the quality of the Illinois coal.

It must be remembered, however, that probably the best coal of Illinois may not yet have been developed. The very valuable iron-smelting, Big Muddy coal, of Jackson County, in the southern part of the State, as well as some of a fair quality in other localities, gives us ground for hope of yet finding coal of a better quality than much of that which is now mined. Certainly, a large amount of coal lately developed, in Western Indiana, is of a much better quality than the coal of Illinois generally; and as we have no reports as yet of thorough explorations of the counties in the central and eastern part of the State, in the vicinity of where the valuable seams of coal on the Indiana side have been discovered, we have reason to expect an extension of them into the eastern part of Illinois. Whatever there may be of value, Western enterprise will develop. The wide distribution and vast extent of the Illinois coal-field

are truly wonderful. Here coal-fields are as inexhaustible as the soil of her fertile prairies.

The United States census of 1870 reports the production of coal in Illinois at 2,629,563 tons. To those accustomed to the very large production of Eastern mines near our seaboard, or large cities, these figures may appear small, but it should be considered that this is but the infancy of the coal business in the West. Many of the mines have been opened a very short time; the country is quite new, and thinly settled; some of the localities are far in the interior, remote from large towns, and many of the particulars which have been mentioned in this chapter are given more as indicating what we may expect hereafter, than for their present importance.

Quantity of Coal of all Kinds annually received at and shipped from Chicago.

YEAR.	Tons Received.	Shipped.	YEAR.	Tons Received.	Shipped.
1852	46,233	1,441	1863	284,196	15,245
1853	88,548	2,968	1864	333,275	16,779
1854	56,775	5,068	1865	344,854	24,190
1855	109,576	12,153	1866	496,193	34,066
1856	98,020	16,161	1867	546,208	69,170
1857	171,850	23,942	1868	658,234	83,399
1858	87,290	15,641	1869	799,000	95,690
1859	181,204	16,886	1870	887,474	110,467
1860	181,060	20,364	1871	1,081,472	96,833
1861	184,089	20,093	1872	1,398,024	177,687
1862	218,423	12,917			

XX.

WESTERN KENTUCKY.

In the western part of Kentucky, the whole of ten counties, and a part of five others, are embraced in the middle coal-field of the Mississippi Valley, or that which lies partly in Illinois, partly in Indiana, and partly in Kentucky. The approximate boundaries of this coal-field are as follows: Commencing on the Ohio River at the mouth of the Tradewater River, near the line between Union and Crittenden Counties, it runs up the valley of that stream, whose course very nearly coincides with its southwestern limits, and forming the western line of Webster and Hopkins Counties. From near the sources of Tradewater, in the northern part of Christian County, its southern boundary runs by the head-waters of Pond River, and near the line dividing Muhlenburg, Todd, Logan, and Butler Counties, crossing Muddy River near its forks; thence through the southern part of Butler County, crossing Barren River between the mouth of Gasper River and the junction of Barren River and Green River; thence east, along the divide between those rivers, through Warren and Edmondson Counties, to near the mouth of Nolin Creek; thence nearly north, to the mouth of the Dismal Creek, omitting an outlier running east to the boundary of Grayson and Hart Counties; the main boundary takes from Dismal Creek a northwesterly course, south of Grayson Springs, near the sources of Clay-Lick and Cany Creeks, toward the Falls of Rough Creek; thence north by the sources of Panther Creek, nearly along the line dividing Hancock and Breckenridge Counties, until it strikes the Ohio again at the Great South Bend, near the limits of the above counties. All the territory included between this line and the Ohio River may be regarded as

belonging to the coal-formation. It includes the counties of Union, Webster, Hopkins, Muhlenburg, Butler, Hancock, Ohio, McLean, Daviess, and Henderson, and parts of Crittenden, Warren, Edmondson, Grayson, and Christian; and by the survey made by Sydney S. Lyon, assistant geologist, it contains 3,888 square miles, making, with the eastern coal-field, 12,871 square miles in all, of coal in Kentucky. (*See* map, p. 388.)

There is an extensive uplift and dislocation of the geological formation, breaking its continuity immediately on the Ohio River. It stretches from Gold Hill, on the Illinois side, across the bed of the river at Shawneetown, to Bald Hill, in Union County, and it has been traced in a nearly east and west course, through the entire county of Union, Kentucky; then, with an increased width, to the east boundary of Henderson County; and it is probable it can be traced completely through the coal-field. It has implicated, in its movements the sub-carboniferous limestone, the millstone grit, and the entire coal-formation which lies in conformable dip on either side of the axis. For a limited space along the Ohio River, this Shawneetown fault has rent asunder the coal-measures, but in the interior of Union County the coal-measures occur on both sides of the disturbance.

Prof. Owen, or some one of his assistants, in making the geological survey of Western Kentucky, fell into an error caused by this fault, in regard to the number of coal-seams, and made an erroneous division of the coal-measures. What were designated, in the reports of that survey, upper coal-measures, and a supposed third series of coal-seams above the upper coal-measures of Pennsylvania and Ohio, turn out to be merely a repetition of the lower coal-measures of the Kentucky section seen at another outcrop, where the shales have an increased thickness, and have thus been mistaken for distinct beds. Thus, he doubled the thickness of the coal-measures and the number of the coal-beds. H. D. Rogers, in the final Pennsylvania report, expressed a doubt whether an error had not been committed by the explorers of this field, leading to an over-estimate of the thickness of the formation. It is a region intersected by a series of dislocated undulations of the strata, and by faults of considerable magnitude, and, through one or both of these sources of fallacious measurement, certain parts of the coal-

measures have chanced to be counted more than once. The error was discovered after the four volumes of Kentucky Reports were published, and acknowledged by the man who made them, but it detracts very much from the value of those reports, and requires care, in using them, to avoid these errors. The study of the coal-field of Western Kentucky is, therefore, attended with unusual difficulty, owing to these errors committed by the State geologist, who made the survey which was continued from the years 1854 to 1860:

"The identification of the Western coal-beds has turned out to be one of our most difficult and important practical geological problems. In the upper Ohio region it was solved thirty years ago, and without the aid of fossils, because the outcrops of the large beds were exposed along ten thousand hill-sides, and could be followed yard by yard, and mile by mile, from ravine to ravine, and from basin to basin.

"But, in the Lower Ohio, Mississippi, and Missouri region, great obstacles were encountered: first, in the small, or varying size of the beds; secondly, in the absence of those heavy sand-rock strata which form so marked a feature of the Eastern system; thirdly, in the low and level character of the country, which keeps the horizontal coal-beds underground for great distances; and fourthly, in the covering of modern sands and clays known as the Northern Drift. Owen, Worthen, Winchell, Swallow, Daniels, and other Western geologists, worked away for years to clear up the confusion, and construct the 'column of the coal-measures.' Of course, they made many a mistake before they got even a general sketch correct; and there is still much to be done to make that sketch a truthful picture, sincere in all its details. Where it could be done, they traced the outcrops. When these went under water-level, or were concealed by drift, they used salt-well borings, and the short coal-mine shafts sunk by individuals or companies. Finally, they betook themselves to the fossils, and received important assistance from this source. The work is still going on. It is in the hands of a variety of men, some of greater and some of less ability; some experienced in that field, and aware of past mistakes, and the rectifications of them; others new-comers, not well posted up.

"The most important of all the blunders committed by the

first explorers was that caused by not sufficiently observing the effects of the Shawnee fault which passes across the northern part of the coal-field of Western Kentucky. It was an immense blunder. It *doubled* the West Kentucky coal-measure section — doubled the number of coal-beds and intervening sand-rocks, and threw every thing into confusion. The European fancy for 'faults' has not been very mischievous in America. But, in this case, they ignored a fault on the Ohio River, near Henderson, which did the business. The mistake was, however, discovered, and nothing assisted to the discovery more than Mr. Lesquereux's study (by Owen's orders) of the East Kentucky coals. This unfortunate mistake retarded for a time the proper arrangement of the South Illinois and West Indiana coal-beds. But Mr. Lesquereux as a paleontologist is not responsible for that. On the contrary, the first identification of the beds at Duquoin and Carlinville was correctly based on the study of the fossil plants."—*United States Railroad and Mining Register.*

The same erroneous system is mentioned in Owen's report on Arkansas, in describing the general system of coal-measures in the United States. His report of the first survey of Indiana was also made on the erroneous basis of the Kentucky Report, and the first two volumes of the Illinois survey assumed the parallelism of the Illinois coals with those of Kentucky, as represented in Owen's reports. Profs. Worthen and Lesquereux, in 1869, discovered the error, and proved that there are, in fact, but about 600 feet of coal-measures, and about 10 seams of coal, large and small, and these containing workable coal, in Illinois, only in the lower 300 feet.[1] The Anvil rock-sandstone, of Kentucky, proves to be the same as that which was there called the Mahoning sandstone, and the coal-beds between them are the same as those below the so-called Mahoning sandstone.

Prof. E. T. Cox, the State geologist of Indiana, in his reports for 1869 and 1870, also shows that there is no natural division in the Western coal-fields into upper and lower coals. From observations made by him, in the same localities that furnished the data of the Kentucky reports, he finds the depth of the carboniferous rocks, in Union County, Kentucky, only

[1] Prof. E. T. Cox, of Indiana, claims priority as to this discovery.

612 feet, including the millstone grit. He found, too, three coals of a few inches in thickness below the millstone grit, and above it, nine coal-seams. The following table shows the corrected section of Western Kentucky, given by Dr. Cox, and that by Prof. Worthen:

Prof. E. T. Cox.	Feet, Rock.	Feet, Coal.	Prof. A. H. Worthen, from his two sections, 3 Illinois Report, p. 7.	Feet, Rock.	Feet, Coal.
Shale and thin Coal, No. 9.		3	Anvil Rock, or Mahoning Sandstone.		
Rock	86				
Coal No. 8		2			
Rock	46		Shale	10	
Coal No. 7		5	Coal		
Rock	41		Shale	40	
Coal No. 6		2½	Coal		5
Rock	65		Shale	60	
Coal No. 5		5	Coal		3
Rock	86		Shale	25	
Coal No. 4		2½	Coal		½
Rock	90		Shale	130	
Coal No. 3		3			
Rock	24				
Coal No. 2		4	Coal		2½
Rock	140		Shale	110	
Coal No. 1		2	Coal		1-3
Millstone Grit	180				

We shall therefore be obliged to confine ourselves, in the use of the Reports on Western Kentucky, to such portions of them as are known to be correct, such as the enumeration of coal-beds found in certain localities, referring the reader to the very full account given of the Illinois and Indiana parts of the same field, in Chapters XVIII. and XIX., made on the corrected basis of the strata for such identification of the seams of coal as can be obtained. This correction of the Kentucky series of strata, reducing the number of coal-seams and the thickness of the coal-measures, brings them to correspond with the general law of a declining gradation westward, in respect to both the measures and coal-seams, which now appears to prevail everywhere. No workable sub-conglomerate coal has been found in the coal-field of Western Kentucky, nor in fact any below the Bell or Tradewater coal No. 2 of the preceding sections; although in Eastern Kentucky numerous localities have been described in Chapter XIV., in Rowan, Morgan, Bath, Powell, Estill and Pulaski Counties, where one, sometimes two, and even three workable beds of coal occur under the conglomerate, all of which underlie what are usually regarded as the productive coal-measures. In the Western coal-field are four prin-

cipal seams of coal, being Nos. 2, 3, 5, and 7, of the above sections, and, among these, cannel-coals are very common in Kentucky.

Coal No. 2 of the above sections is mentioned by Dr. Cox, in his report of 1869, as seen at Cannelton, Indiana, at Hawesville, on the opposite side of the river, and at Bell & Casey's mines, on Tradewater River, a few miles to the eastward of Caseyville, on the Ohio River, in Union County, Kentucky. It is a generally-recognized synchronism over a broad area of the coal-measures, for the first bed of coal above the conglomerate that is of sufficient thickness to be economically worked. Assuming this coal to be correctly placed, there is, thirty or forty feet above it, a thin seam that is nowhere, over the district mentioned, thick enough to be worked.

Above this are two or three less important coal-seams, and then near the head of the series is another good workable bed. In the Kentucky Reports Prof. Lesquereux gives an interesting account of the paleontology, stratigraphy, and distribution of the coal-seams, but their distribution he found it difficult to show satisfactorily. The seams are all more or less subject to modifications, which alter their appearance even at short distances. They thicken or thin out, separate or multiply. Others, which are generally found separated by sandstone or shales of various thicknesses, join and become united in a single bed of coal.

Of the coals above the conglomerate, the first, or No. 2 of the above section, is the most reliable, and most extensively developed in both fields in Kentucky, where it is generally the depository of cannel-coal, and it is also the most variable. It is, however, the most reliable, both as to its thickness, extent and persistency, of any bed of the whole range of the lower coal-formation. A coal in this position apparently extends without interruption, except accidental ones, over the whole coal-fields of the United States. Its average thickness in Kentucky is four to six feet. In this western basin it generally has a clay parting from one to six inches thick, and in the eastern two or three, which thicken, disappear, or change their nature, in the most unaccountable manner. Prof. Lesquereux, whose forte is paleontology of the coal-measures, says the plants of the

genus *Lepidodendron* or scale-tree, which appear to have had their greatest development at the time of the formation of his coal No. 1 B, or No. 2, of the above sections, gradually diminished, and eventually totally disappeared, so that, at the epoch of the formation of the upper workable coal, there was scarcely a representation of this genus.

After a careful examination of the Kentucky Reports, with the aid of the corrections pointed out in those of Illinois and Indiana, it appears to be safe to say that there are generally at least two good workable beds of coal in the Western Kentucky coal-measures above the conglomerate, and these are situated, the one, the first good seam, above the conglomerate, and the other 25 or 30 feet below the coarse sandstone mentioned, which has been variously called the Mahoning, the Curlew, and the Anvil-rock, which are now understood to be one and the same thing.

The uncertainty as to the true position of many of the numerous coal-beds described in the Kentucky Reports of Prof. D. D. Owen and his assistants, renders it necessary to omit descriptions of many of the smaller seams. They reported no less than eighteen different beds of coal near Uniontown, with a united thickness of 43 feet, divided into three groups, the lower subdivision containing 13 feet, the middle 24 feet, and the upper six feet. High up in the series another coal-bed has been opened in many places, and extensively worked in the southern part of the western coal-basin of Kentucky, where it is generally 3 to 3½ feet, and near the county line of Hopkins and Christian Counties it is 4½ feet. The coal of this seam is of excellent quality; indeed, for domestic use and the generation of steam, it is one of the best. It is generally compact as a seam, but sometimes divided into two by a thick shale parting, and its average thickness is from three to five feet. It is situated at the base of a great, hard, mostly conglomeritic sandstone, 20 to 100 feet thick, containing large pieces of fossil wood. These pieces of wood are not merely prints, but they are transformed into charcoal or silicified trunks. This rock was supposed by the Kentucky geologists to be the same as the Mahoning sandstone of Pennsylvania, and in Muhlenburg County it is 75 feet thick or more.

The following statistics from the fourth volume of the Kentucky Reports are of such a character as not to be affected by the errors referred to in the column of the coal-measures. At Bell's mines, in Crittenden County, on the Tradewater River, coal No. 2, the first workable bed above the conglomerate, is five feet thick, and it is of the same size at Casey's mines in Union County, on the west side of the same river. About 50 feet above Bell's mine a seam of coal is found two feet thick. The greatest advantage of these localities is their vicinity to the Ohio River. Along the Tradewater River it has been extensively worked, also close to the Ohio. There are also numerous outcrops, in the interior of Union County, of coal five feet thick. Its production is the largest in the State.

But Hopkins and Webster Counties, situated farther up the Tradewater River, have in store for the future by far the greatest provision of coal in this western basin. Its wealth in this mineral is truly beyond computation. The town of Providence, in Webster County, is at the top of a hill, around which three beds of coal, each from five to six feet, are exposed in scarcely 125 feet of measures. In numerous localities these outcrops are of easy access, and are seen on the slopes of the hills or the bottom of the valleys, where they are sometimes exposed for long distances in the cuts of the creeks. In the southeastern part of the county the waters of Clear, Lamb, Richland, Stewart, Casey, and Pond Creeks and their numerous tributaries, seem to run for no other purpose than to expose thick coal-banks along their course, and to prepare gentle and easy slopes for the mining and transportation of the mineral. In the same vicinity there is an agglomeration of small mountains, which from the base to the top look like a succession of coal, iron, and limestone strata, heaped there as an inducement to labor and capital. Until railroads are built here, as they might be between nearly continuous coal-banks, a mineral wealth, of more real value than all the gold of California, must lie dormant in the heart of a fertile country, from the want of easy communication. Numerous localities are mentioned in Hopkins County, where coal-beds, three, five, and even six feet thick, have been opened.

Along the southern edge of the basin across Christian,

Muhlenburg, and Butler Counties, from the mouth of Casey Creek on the Tradewater River, as far east as Morgantown on the Green River, there are two workable coal-beds in close proximity, the upper four to five feet, and the lower one to 3½ feet; but many places are mentioned where coal is found four, five, and six feet thick. It is only along the Green River that coal has been worked with some activity, but it is impossible to make a just appreciation of the mineral wealth of Muhlenburg, Ohio, McLean, Daviess, Hancock, and Breckenridge Counties. The difficulties of profitably using or transporting such rough material as coal prevent even careful researches to ascertain the extent and character of these great stores of fuel.

By the census reports of 1870, the Western Kentucky coal-field produced 115,094 tons of coal, of which Union County mined 67,466 tons, and Crittenden 23,600.

FOURTH COAL-FIELD.

XXI.

IOWA.

During the years 1855–'57, a State geological survey of Iowa was conducted by Prof. James Hall, of Albany, New York, assisted by J. D. Whitney and A. H. Worthen, who became afterward the State geologists of California and Illinois, respectively. Their investigations were confined principally to the eastern half of the State, and the results were published in two volumes. After an interval of nearly ten years the work was resumed, and prosecuted from 1866 till 1869, under the direction of Dr. Charles A. White, whose report is also contained in two volumes, published in 1870. Although there is much more to be done at some future time, yet both these surveys are very creditable to the State, and give us an excellent account of the character and extent of the coal-field of Iowa.

The following is a summary of both of these reports, so far as they relate to the coal-region, the materials being taken from each, and arranged as they appeared to be applicable. The general geological series of Iowa is as follows, the numbers being in the ascending order:

VI.	Carboniferous, Upper, Middle, and Lower, each 200 feet...	600	feet.
V.	Chester Limestone, wanting in Iowa....................	00	"
IV.	St. Louis Limestone..................................	75	"
III.	Keokuk Limestone....................................	90	"
II.	Lower and Upper Burlington Limestone.................	190	"
I.	Kinderhook Beds (Chemung Group of Hall)..............	175	"
	Hamilton, Niagara, Trenton, and Primordial............	1,760	"

The Chester limestone is not found in Iowa, but the other four sub-carboniferous limestones are well developed; the Keokuk and Burlington, however, occupy a very limited area, while those above and below them, the St. Louis and Kinderhook beds, occupy a much larger area than any of the others. From these facts, Prof. White offers the following conclusions:[1] That from the Potsdam period to the close of the Kinderhook period, there was a regular and gradual recession of the sea to the southward. In the early part of the Burlington period, there was a very marked recedence of the sea, so that this limestone did not reach farther north than Johnson County. This recedence continued till the close of the Keokuk limestone period. Then the St. Louis limestone sea reoccupied nearly the whole area formerly occupied by the Kinderhook beds. At the close of the St. Louis limestone epoch, there was so extensive a recedence of the sea, that the Chester limestone did not probably reach within 200 miles of the southern limit of Iowa. At the close of the last sub-carboniferous epoch, there was another remarkable reoccupancy of shallow seas, so that the coal-measures received their first deposits not only on the surface of the St. Louis limestone, but also overlapped upon the Kinderhook rocks; and doubtless others besides, for we have no assurance that the outliers before referred to were not at one time connected parts of the great coal-formation.

Following this regular recession of the lower rocks, the divisions of the coal-measures again show the same gradual recession to the southwest, together with a similar general direction of trend that the older rocks do. Thus, in the Iowa coal-field, we always find the lower coal-measures at the north border; next in order come the middle, and then the upper, still farther within the field. The lower coal-measures alone are found along the Des Moines River, and to the northward and eastward of it. The upper coal-measures lie wholly to the southward and westward of that river, which passes through the productive or accessible coal-field of Iowa, as now determined, near its centre. The receding borders of the upper coal-measures rest conformably upon the lower series, and do not reach the north and east border of the coal-field, nor do they

[1] In an article in *Silliman's Journal.*

lap upon the rocks of older date than the lower coal-measures, as they are supposed to do in Illinois, although the lower coal-measures do rest on lower rocks of different ages.

The stratigraphy of the whole region is very simple; the line of strike being practically east and west, and the dip to the southward, nearly coincident with the fall of the streams. In the lower half of the coal-field, particularly along the Des Moines and Skunk Rivers, and their branches, the valleys are often found to have been eroded, through the coal-measures exposing the St. Louis sub-carboniferous limestone. But, in Marshall and Hardin Counties, the coal rests on the Kinderhook beds. Thus, the want of the Chester limestone throughout the field, and the overlapping of this northeast corner of the field, is the only unconformability of the coal-measures of the principal coal-field. But we will see there is greater unconformability among the members of the sub-carboniferous period. The coal-region of Iowa seems to differ in no respect from that of Illinois, from which it is only separated by the river-channel of the Mississippi, which is a valley of denudation. Where the coal outcrops approach each other as at Keokuk, it is quite evident that the coals on the two sides of the river were continuous beds, the lower coal-seam, as well as the strata of sandstone and shale, corresponding in character and thickness. There is no evidence of the existence of an anticlinal axis along the course of the Mississippi River. Neither is there evidence of the occurrence of a single fault or dislocation of the strata, either in the beds belonging to the coal-measures, or in the underlying limestones. The differences of level at which the same beds appear, at various localities, are due rather to the undulations of the underlying limestones, and the consequent irregular surface upon which the coal-measures have been deposited, which was formed into troughs and depressions.

The same peculiarity which has been mentioned in the description of the Illinois coal-field, is also found in Iowa, as to the coal-measures resting unconformably upon successive strata of the Lower Silurian, Upper Silurian, Devonian, and Carboniferous limestone, such as the Potsdam, Calciferous, and St. Peter's sandstones, Trenton, Niagara, St. Louis, and other limestones. This renders it the more difficult to follow out and

determine the boundaries of the workable coal-beds, as those formations do not correspond to the general direction of the inferior groups, nor have they participated in the general movements which disturbed and elevated those lower strata; consequently no outline of any one of them will aid in determining the limits of the coal-formation. The nature of the country, too, which is deeply covered with drift and later deposits, adds to these difficulties.

The coal-measures of Iowa are properly separable into upper, middle, and lower divisions. The lower and most important, being the coal-producing portion, occupy the surface of an area averaging some 50 miles in width, and about 175 miles in length, through the middle of which the Des Moines River runs longitudinally in a southeasterly direction, from a little above Fort Dodge, nearly to Keokuk. On almost the whole of this large surface coal may reasonably be sought for, and has been quite extensively developed. To the northward and eastward of it, it is useless to look for coal, except in small patches, or outliers. To the southward and westward of this region it is believed that coal will be found by sinking shafts to a greater or less depth.

Next, in a southwesterly direction, occur the middle coal-measures, overlying the lower in the same general form, appearing on the surface in a tract extending in a southeasterly direction. It produces only one or two thin, uncertain seams of coal.

Farther toward the southwestern part of Iowa the upper coal-measures overlie the middle and lower, occupying an area equal in extent to that of the State of Vermont. These are also without valuable seams of coal, except a thin seam in one locality; so that a large portion of the Iowa coal-deposits seems to be deeply buried at an unknown depth, thus giving greater importance to that which is accessible.

The boundaries of the coal-field of Iowa have been well defined by Prof. White, on the geological map accompanying his report. It corresponds nearly with the east line of Van Buren and Jefferson Counties, curving a little eastward into Lee, the southeastern county of the State. From the northeast corner of Jefferson County the line pursues a nearly northwest course,

passing near the northwest corner of Keokuk and the northeast corner of Mahaska County to the middle of the south line of Marshall County. Then it runs to a point three or four miles northeast of Eldora, in Hardin County; thence westward to a point a little north of Webster City, in Hamilton County, and thence still farther westward to a point a little north of Fort Dodge, in Webster County. Farther west it is uncertain.

The line of division between the lower and middle coal-measures is a nearly southeasterly course, so as to include in the lower coal-measures a part of the counties of Guthrie, Dallas, Warren, Lucas, and Appanoosa. The area between these two boundary-lines embraces the most important and accessible portion of the coal-field of Iowa, containing 6,100 square miles, and the middle 3,400 miles. The thickness of the formation of the lower coal-measures is estimated at about 200 feet. Beyond, or eastward, the line first described, and resting upon both sub-carboniferous and Devonian rocks, numerous small outliers of lower coal-measure strata exist. One of considerable extent is found resting upon the Devonian rocks, and reaching from Muscatine nearly to Davenport.

Almost all the coal of Iowa is found in the lower and middle coal-measures, and much the greater part in the lower, which is composed principally of sandstones and shales, the best beds being found in the lower part. This seems to be a well settled fact, that this lower series alone can be properly designated as the productive coal-measures of Iowa, since the upper series is now understood to contain but one bed of coal, the maximum thickness of which is only twenty inches, and its greatest development is along the Nodaway River.

The boundary between the middle and upper coal-measures is described as follows: Draw a line from the northwest corner of Harrison County, almost directly to the middle of the northern boundary of Madison County; thence to the middle of the northern boundary of Wayne County; thence to Centreville, and thence to the south boundary of the State along the west side of the valley of Chariton River. These upper coal-measures, containing 8,500 square miles, extend not only to the western and southern boundary of the State of Iowa, but also, with-

out interruption, far into the States of Missouri, Nebraska, and Kansas.

The sub-carboniferous formation of Iowa consists principally of limestone, with scarcely any carboniferous matter. But the lower coal-measures, almost from their beginning, are sandstone and shale, and among them the beds of coal and fire-clay. In the middle coal-measures there is an increased amount of limestone material, although they are principally characterized by shales and sandstones. But, when we come to the upper coal-measures, there is another abrupt change from rocks composed of sand and clay, to a formation as fully characterized by limestones as any of the formations of the sub-carboniferous group.

On the north side of the Des Moines and the Iowa Rivers the coal-beds are usually thin, rarely more than 2½ to three feet thick, with the exception of Martin's Creek, near Hillsboro', where the two lower seams, one three and the other four feet thick, approach within 10 inches, so as to be wrought as one seam. It seems quite probable that all the coal on the north side of the Des Moines River occurs in detached, isolated patches or basins, some of them at least of very limited extent, and bounded by the outcroppings of the underlying limestone. If future examinations should prove this to be so, then Iowa must depend on the region south and west of the Des Moines for a future supply of mineral fuel. The great body at least of the coal-region of the State is believed to be to the southwest of the Des Moines, where the coal-seams are believed to be thicker and better than along the edges of the basin. There are extensive districts on the north side, over which the superficial deposits are so deeply spread that but little more can be said of it, than that in all probability they are in part occupied by limited patches of rocks belonging to the coal-measures, but whether these are workable beds of coal can only be decided by expensive explorations, which will be made after the country is more thickly settled.—(*Hall.*)

There seems to be no regularity, says Prof. Hall, in the number or thickness of the beds of coal in the region examined, even at localities which are comparatively near each other, the whole arrangement of the materials of the coal and

the associated rocks indicating great irregularities in their modes of deposition, and of the surface on which their accumulation took place. There appear to be, in most of the localities where the rocks are best exposed, two beds of coal; and, when best developed, the heaviest may sometimes reach five feet in thickness on the south side of the Des Moines River, but on the north side the beds have rarely exhibited that amount of good workable coal. A little west of Ottumwa, on that river, there is a thickness of five feet of good coal exposed, and probably a second seam which has not yet been found.

Prof. Worden's report on several counties lying on the Des Moines River gives the thickness of coal in many localities. Ascending the river, he reports in Van Buren County two seams of coal, one of which is from three to five feet thick. In Jefferson County the beds are exceedingly variable in thickness; a seam three feet thick at one point may thin out to as many inches in a distance of two or three miles, or perhaps entirely disappear, and appear to be very irregularly deposited. The lower seam is the most reliable, and contains less sulphuret of iron in this county than almost any other found in the State. Farther up the Des Moines, Wapello County is nearly wholly underlaid by at least two coal-seams, averaging from two to five feet thick each. Above this the exposures of rock were not satisfactory in 1857, and no good section could be obtained, and the coal-measures are not seen in going northward, until we pass Marietta in Marshall County, but the coal-series probably covers nearly all Jasper and Hardin Counties. In the vicinity of Eldora, in Hardin County, coal is mined from seams 3½ to four feet thick. Numerous other details are given of the coal-seams, as exposed in many places along the Des Moines River, of thicknesses from one to three feet, and sometimes four or five, and in a few localities as much as six or seven feet. What has been stated will give a general idea of the Iowa coal-region at the time of Prof. Hall's report, but at that date it was considered premature to attempt to estimate the number of square miles occupied by workable coal-beds, or to give an approximation to their average thickness, or even a general account of the coal-bearing strata of Iowa.

The Coal-producing Counties.

The coal-producing counties of Iowa, by Prof. White's report, are those on each side of the Des Moines River, from Fort Dodge in a southeasterly direction, to the Mississippi River. In Webster County, at least three distinct beds of coal have been identified, of which the upper one is the thickest, purest, and consequently the most valuable. They are accessible along the Des Moines Valley and its tributary creeks, and there can be no doubt that they may be reached by shafts from the prairie surfaces over four-fifths of the county, which is occupied by the lower coal-measures. One of these beds, perhaps the lowest, has been for some time successfully mined at Fort Dodge, but the best and most abundant supply is obtained four or five miles below the city. The principal bed worked there measures from five to six feet in thickness. This promises to prove the vicinity of Fort Dodge to be one of the most important portions of the Iowa coal-field, notwithstanding its close proximity to the border. This bed alone will furnish immense quantities of coal, both for local use and for shipment.

In Hamilton County only one valuable bed of coal was satisfactorily made out by Prof. White, which was four feet thick at its natural exposures. The productive coal-measures occupy the greater part of the county. In Hardin County, a workable bed of coal has been found at Eldora only, but the coal-measure strata are found exposed in the valley of the Iowa River at intervals from the point where it enters to where it leaves the county. The bed of coal is four feet thick, and the mines at Eldora are of great importance and value, being on an extensive scale for this country, and shipping much coal upon the Central Railroad of Iowa, and the Dubuque & Sioux City Railroad. Aside from the intrinsic value of these mines, the importance of the region is much enhanced by being the most northeasterly one within which coal has been or is likely to be obtained. Some excellent potteries are established at Eldora, using the fire-clay from the bed which underlies the coal.

The whole of Boone County lies quite within the limits of the Iowa coal-field, yet, owing to the great depth of the drift, coal has actually been discovered at only a few points near its

centre. Coal has been extensively worked near Boonsboro' and Moingona, upon the line of the Chicago & Northwestern Railway, all the mines being opened in the valley-sides of the Des Moines River and Hovey Creek, one of its tributaries. There are two distinct beds of coal known and mined here, the principal one, being the lowest, is about four feet thick, and the upper one 2½ to 3 feet thick, the quality of the coal in both being the same. These being the only mines yet opened on the line of that railway in Iowa, they are of great value and importance. There can be no reasonable doubt that these, or other beds of coal, may yet be reached by sinking shafts upon the prairie surfaces of different parts of the county at a comparatively moderate depth. Production in 1870, 42,143 tons.

In Story County, east of Boone, no workable bed of coal has as yet been discovered. The indications are, that the base of the coal-measures is not far from the surface, but there is no reason to doubt that a workable thickness may yet be found within its limits. In Marshall County, east of Story, all the coal will be at a comparatively slight depth, and it will only be found in the western and southwestern part of the county.

At Des Moines, the capital of Iowa, coal is extensively mined at several points near the place, supplying that whole city and vicinity, the railroad companies for their own use, and also a considerable quantity for shipment. These mines are all opened in the valley-side of the Des Moines River, and are all in the same bed, consisting of three separate seams which have here come so closely together that they are readily mined like one bed, either one of which would be too thin for profitable working if alone. This compound bed has been recognized as far west of Des Moines as Redfield, in Dallas County, and as far southward as Indianola, in Warren County. Polk County is nearly centrally located among the coal counties of Iowa, and large quantities of coal may be reasonably assumed to exist beneath its surface. Production in 1870, 45,600 tons.

East of Polk is Jasper County, another of the coal-producing counties. The coal is quite extensively mined near the central portion of this county at several points a few miles southward and westward from Newton, the county-seat. The coal-seam is about four feet thick, and the coal produced is of a good average

quality. The county lies quite within the recognized limits of the coal-field, and large supplies of coal may be reasonably relied upon for the future. Production in 1870, 20,720 tons.

Warren County, south of Polk, Prof. White thinks, will some day rank among the best coal counties of the State. This, together with the two other counties immediately east of it, Marion and Mahaska, seem to be, probably, the very best coal counties of Iowa.

In Marion County, except in the immediate vicinity of the Des Moines River, a shaft 200 to 300 feet deep could hardly fail to pass through one or more coal-beds, and at least three different beds of coal exist in the county. Prof. White mentions numerous mines and natural exposures of coal within the county, showing some beds of remarkable size. Near Pella and Otley Stations, on the Des Moines Valley Railway, numerous mines have been opened in beds of coal varying from four to six feet in thickness; occasionally seven, and in one instance in this county ten feet of coal has been found, and there is hardly a limit to the number of mines that could be conveniently opened in Marion County.

Mahaska County, which is situated east of Marion, is quite as important as regards its supply of coal, and it is much in advance of any of the others in its annual production of coal. At Oskaloosa station, two and a half miles from the town, which is 99 miles from Keokuk, on the Des Moines Valley Railroad, the most important coal-mines yet opened in the State are located, the coal presenting a thickness of from five to nearly eight feet in thickness. Prof. White also describes other mines in various parts of Mahaska County, with a thickness of four to five and a half feet.

Keokuk County lies near the eastern border of the coal-field, where the coal-formation would naturally be expected to be thinner. However, some good mines are already opened there.

The northern part of Monroe County, the principal part of Marion, the southern part of Mahaska, and the northwestern corner of Wapello Counties, constitute what is now regarded as the finest part of the Iowa coal-field. Coal-beds, from four to five feet thick, are opened in the northern and eastern part

of the county of Monroe. In other parts of Monroe County, the middle coal-measures are found resting upon the lower, and these contain thinner coal-seams than the latter.

Wapello County, in which Ottumwa is situated, where the Burlington & Missouri River Railroad crosses the Des Moines Valley Railroad, ranks second only to Mahaska County, at present, as regards the amount of coal annually mined. In the immediate vicinity of the city of Ottumwa, several mines are opened in apparently two separate seams; but they are both rather thin, and the quality of coal inferior.

Four or five miles from Ottumwa, mines are opened in a four-foot bed, and many others are mentioned by Prof. White in this county, on beds of coal from four to five feet thick. At Alpine station, on the Des Moines Valley Railroad, are extensive mines opened, from which large quantities of coal are shipped on the railroad.

In Appanoose County, south of Monroe, and next to the Missouri line, coal has not been worked to any extent, but there is good reason to believe it exists beneath its surface in large quantities. The same remark applies to Davis County, which is east of Appanoose, but there are few natural exposures.

Van Buren County is one of those within which coal was first discovered; consequently some of the oldest coal-mines in the State are located here. In the southeast corner of the State, mines have long been opened in seams from three and a half to four feet thick, and the many openings made in the coal-beds of other parts of this county show that very large quantities of coal exist in Van Buren County, but, there being a competition with the mines at Oskaloosa, and the demand being limited, some of the mines in this county are not operated.

Jefferson County, north of Van Buren, is also a coal-producing county. At Coveport, ten miles eastward from Fairfield, also at a number of points all around Fairfield, numerous mines have been opened, and from some of them much coal is shipped by railroad.

The coal-field extends into the southwestern corner of Washington County, and several counties west of the Des

Moines River, not here mentiond, are well known to contain coal.

There is, also, in Muscatine and Scott Counties, a remarkably large outlier of coal resting upon Devonian strata, and extending from Muscatine nearly to Davenport. It contains a single bed, seldom exceeding three feet in thickness, but of great local value.

On the west side of the Des Moines River, in Guthrie and Dallas Counties, the lower coal-measure strata are seen to pass beneath those of the middle formation, and it is only southerly and southeasterly from here that we find the middle coal-measures on the surface. The line dividing these two formations runs from near the northeast corner of Guthrie County, in a southeasterly course, to the Missouri River.

The middle coal-measures, containing only some thin coal-seams, next occupy a small, narrow region only, and are succeeded by the upper coal-measures, which unfortunately cover a large area in Southwestern Iowa, comprising thirteen whole counties, together with parts of seven or eight others adjoining.

This upper coal-measure formation is characterized by a return to limestone formation, very similar to that found below the coal-measures. It may be considered as destitute of coal, for, although it contains layers of carbonaceous material, they are too impure for fuel, except in the valley of the Nodaway River, in the counties of Adair, Montgomery, Taylor, and Page, where is found a thin seam of coal of very fair quality, but never exceeding twenty inches in thickness.

As to the important question of how far beneath the surface, at any given point in Southwestern Iowa, the workable coal-beds lie, Prof. White remarks that it may be regarded as certain that the lower and middle coal-measures extend beneath the unproductive upper coal-measures to the western and southwestern parts of the State; and further, that, as all the coal-measure formations thin out to the northward and eastward, we might infer a similar thinning out toward the west, and that allowance must also be made for a very natural thickening of the upper or barren coal-measures toward the west. He estimates that a shaft 1,000 feet deep would pass through all the coal-measure strata within the State of Iowa.

The State census of 1868 shows an annual production of coal in Iowa for that year of 241,490 tons, of which more than 200,000 was in the eight counties of Boone, Mahaska, Wapello, Polk, Jefferson, Marion, Scott, and Jasper, this being the order as to production. The United States census of 1870 shows the production of the previous year to have been 263,487 tons. In the Iowa Report, Prof. Hall describes a geological phenomenon of frequent occurrence there, consisting of numerous fissures and cavernous openings in the limestone-rocks, much below the coal-measures, made by running water, and afterward filled with the same successive beds as the coal-measures, sandstone, fire-clay, and coal, the materials having been forced through an opening in the roof of the cavity in regular succession, just as they were formed in their proper places outside and above. There is no mingling of the materials, but each in its turn seems to have been filtered through the fissure by hydrostatic pressure while in a semi-fluid state, and the laminations conform to the curvatures and irregularities of the roof and floor of the ancient caverns which they occupy.

Quality of the Coal (Hall).—The coals of Iowa are all of the bituminous class. They are fat, adhesive, and close-burning, the coke melting down into a solid mass, and therefore requiring frequent stirring to effect a complete combustion. There is no essential difference between the average of Iowa coals and of those of Illinois. They contain from 35 to 40 per cent. of volatile bituminous matter, and from 45 to 50 of fixed carbon, and the amount of ashes varies from 1 to 20 per cent., but in the better class of coals it does not usually much exceed 5 per cent. The amount of water in the different coals examined varies from 3 to 15 per cent. The specimens obtained from the edge of the basin evidently contained more water than those obtained farther to the southwest. This is undoubtedly owing to the greater solidity of the coal, when it occurs in large beds, and has been pressed down by a heavier weight of superincumbent rock. The slowness with which these Western coals part with the moisture which they contain, and which appears to be only mechanically mingled with the carbonaceous matter, is indeed surprising. A sample of coal from the Big Muddy River, in Illinois, which

was collected in 1852, and had remained in a dry place for five years, was found to contain 5.37 per cent. of water on being dried at 212°. A sample from Rock Island, taken from the bed in September, and analyzed in November, 1856, was found still to contain 7.96 per cent. of water, but, after having remained another year in a dry and warm room, exposed to the air, it was ascertained to have parted with over half of its hygrometric moisture, losing at that time only 3.44 per cent. by exposure to a temperature of 212°. Another sample, from Webster County, after remaining about two months exposed to a summer temperature in a dry room, gave 14.95 per cent. of water; the same, after remaining a further period of six months, under the same conditions of dryness, contained only 6.6 per cent. of moisture.

Prof. White reports the proximate analysis of 64 samples of Iowa coals from fifteen counties, showing an average of the whole as follows: Moisture, 8.57; volatile combustible, 39.24; fixed carbon, 45.42; and ashes, 6.77 per cent. The moisture varied from 4.61 to 12.84 per cent.; the volatile combustible from 31.85 to 44.41 per cent; the fixed carbon, omitting a single sample, from 42.38 to 49.55 per cent.; and the ash from 2.16 to 15.97, but with two exceptions the ash did not exceed five or six per cent.

The amount of ash is almost the same as in the average of a large number of samples of Illinois coals, but the amount of fixed carbon is largely in favor of the Illinois coals.

In regard to the practical application of analysis to the valuation of coals, Dr. White makes the following statements: "1. The value of coal as fuel is inversely proportional to the amount of moisture it contains; that is, the more water it contains the less is its value. The moisture is a damage to the coal, not only because it takes the place of what might otherwise be occupied by combustible matter, but also because it requires some of the heat generated by the burning of the combustible matter to transform it into steam, and thus to expel it. It will thus be seen that the presence of large quantities of moisture in coal seriously impairs its value. 2. The greater the percentage of ash the less is the value of the coal. 3. The more fixed carbon which the coal contains, the greater is its

value. 4. The same holds good with regard to the volatile combustible matter, to a limited extent, the precise limits of which cannot be determined until we know the composition of this combustible matter."

Sulphur.—In a practical point of view, however, the most important question, says Dr. Hall, in regard to the condition of the Western coals, is the quantity of sulphuret of iron or pyrites mechanically mixed with the coal, the amount being frequently so considerable as to materially impair its value. There is also often more or less gypsum, and occasionally carbonate of lime, present in the coal, the gypsum and pyrites being frequently associated together, and forming thin plates, filling the joints of the coal. The presence of these substances renders the coal unpleasant to burn, and injurious in its effects on the metals in contact with which it is ignited. Besides this, those coals which contain pyrites and gypsum cannot be kept for any considerable length of time, or transported to any distance, without losing much of their value by slacking or crumbling into small fragments. The quantity of these deleterious substances disseminated through the coal is so variable in different portions of the same bed, and even in samples taken from the immediate vicinity of each other, that a more reliable opinion could be obtained from an inspection of a large quantity of the coal lying at the mine, than from an analytical examination, which is necessarily confined to a small quantity. Much of the Iowa coal is evidently of an inferior quality, owing to the presence of so large a quantity of sulphur, moisture, and other impurities.

Does the Coal-Field extend west of Iowa?—As Iowa is the farthest Northwestern State that contains an extensive coal-region, it is a suitable point from which to take a look westward, and to inquire as to the probability of further discoveries of a similar character beyond the northern and western margin of her coal-basin. Prof. Hall, in the Iowa Report, discusses this question, and, after noticing the important limestone formation everywhere associated with the coal-measures of the West, and the thinning out of the sandstones and mud-rocks of the East, he is forced to the conclusion of the ultimate disappearance of the coal-measures in a western direction also.

In Southeastern Ohio and the adjacent parts of Pennsylvania and Virginia, thin beds of limestone are found associated with the coal-measures. One or more of these bands extend westward over a large area through Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska, with a constant increase in thickness and importance as we pass westward, while there is a palpable diminution in the thickness of the sedimentary rocks, or the shales and sandstones of the coal-measures. The Western coal-measures thin out to one-tenth or one-eighth of the thickness they have in Pennsylvania. This alone should prepare us to find ultimately that the productive part of the coal-measures would also thin out in great part, or entirely, in that direction. Tracing the limestone westward, we find that, from being subordinate to the coal-measures proper, the latter become subordinate to the limestone, and still farther west it is a vast limestone formation, thousands of feet in thickness, the product of a wide and deep ocean. But the conditions favorable to the production of an extensive deposit of marine limestone are not such as usually accompany the production of coal. Land-plants in excessive growth, and shells such as are found in shallow water, are found in the strata accompanying coal. During the oscillations which have occurred during the coal-period, the waters of the ocean which covered the Mississippi Valley invaded the Western coal-fields as far northward and eastward as the northeastern part of Ohio, and formed there limestones. But, as the waters deepened toward the west and southwest, the conditions were never such as to admit of the production of coal-plants and such materials as make up the coal-measures.

In the East, on the contrary, we have good reason to believe that dry land existed near our present continent from the earliest geological times. The Potsdam sandstone was a universal formation, which spreads everywhere over the entire breadth of the continent, from the Rocky Mountains to the Atlantic. Subsequent to this, however, every one of the sedimentary formations indicates the proximity of land on the east. The Hudson River, the Clinton, and other groups, the Hamilton, Chemung, and Catskill, all indicate proximity to land, or the course of strong currents in the East, while, in the West

they die out into beds which, in their size and materials, indicate great distance from land, and a quiet ocean. This whole series of the Upper Silurian formations, forming a vast accumulation of land-derived materials of 4,000 to 6,000 feet in Pennsylvania, says Prof. Hall, has diminished here to less than 200 feet of deposits in the valley of the Mississippi, and all these marked by marine fossils only, and the Hudson River and Oneida conglomerate from 7,800 feet to 100 feet. We therefore, he says, cannot expect the coal-formation, with its land-derived materials, and its abundant land-plants, will prove an exception to the general rule.

It would therefore appear that, from the earliest Silurian times, the great West, or the region of the Rocky Mountains, has been an ocean, not only to the close of the Carboniferous period, but still later, showing no evidences of dry land till the Cretaceous era. It was a little later in the Cretaceous, or earlier Tertiary period, that the far Western continental flora have been developed over the same area to a remarkable degree, producing the materials of the great Cretacean or Tertiary coal-fields of the Rocky Mountains.

In the mean time, the part of the country east of the Mississippi being elevated and finished, rock-making here ceased, while a vast amount of the later formations were formed along the line of the Rocky Mountains, from one end of the continent to the other, including another larger, newer coal-region, producing a different species of fuel.

XXII.

NEBRASKA.

The following article, on the possibility of finding workable beds of coal in Nebraska, was published in *Silliman's Journal* for May, 1868, and is from the pen of Prof. F. V. Hayden, one of the most distinguished American geologists, who, since 1853, has devoted the greater part of his time to the development of the geology of the great region drained by the Mississippi River and its tributaries. During that period he has personally explored the greater part of the Territories of Kansas, Nebraska, Dakota, Montana, Idaho, Colorado, Utah, and New Mexico, and, as United States Geologist, he is making further examinations throughout our Western Territories.

During the geological survey made by him in 1867, the greatest interest was felt by the people in the question of the existence of workable beds of coal in Nebraska, from the fact that nearly all the State is a treeless prairie. A bed of coal of even moderate thickness, at a reasonable depth, would be of inestimable value, and the solution of this problem seemed to be the most important one of the survey.

It is now pretty well proved that in the upper coal-measures of the West there are no workable beds of coal, and that, while thin seams occur in many places, they never attain a thickness of more than 2 or 2½ feet. It is also now known that all the carboniferous rocks of Nebraska belong to the upper coal-measures, or Permo-carboniferous, and that even these rocks occupy but a small area in the southeastern portion of this State. In ascending the Missouri, they pass beneath the water-level of the river near De Soto, about 30 miles above Omaha. The area occupied by them widens southward; but it forms only a narrow strip, hardly two counties wide, even at the

south boundary of the State.[1] Overlying the upper coal-measure rocks are a series of Permio-carboniferous beds, which are found in Kansas, a portion of the coal-measure fossils passing up through them, and Permian types passing down. Still holding a higher position, especially in the valleys of the Big and Little Blue Rivers, are some beds of yellow, soft, magnesian limestone, which seem to be only a northern extension of what Meek and Hayden regarded as Permian in Kansas. Overlying these are the Cretaceous rocks, especially west by north of the Dakota group. There is, however, no break in the order of sequence of the beds from the coal-measures to the summit of the Permian. The true Permian, however, does not occur in Nebraska, or, if it does, it is found only in isolated areas.

Prof. Hayden then goes on to mention the different outcroppings of coal in various portions of the State, because their existence seemed to the people to promise better things. The consequence has been, that much more money has been spent in the useless search for coal in Nebraska, than the cost of a geological survey for years.

Near Nebraska City, on the Missouri, an outcropping, about eight inches thick, has attracted some attention. It has been wrought by drifting-in a distance of 300 yards or more, and several thousand bushels of pretty good coal have been taken from it. At Brownsville there is a seam of coal, probably holding a lower position than the one at Nebraska City, which is accompanied by several species of plants peculiar to the upper coal-measures. The seam is from four to six inches in thickness, but the whole bed of black shale and coal is about 12 inches thick. At Aspinwall, in Nebraska County, two seams of coal were met with; one of them, high up in the hills, is probably the same as that just mentioned at Brownsville, while near the water's edge another seam is disclosed about 22 inches thick. Some English miners have commenced sinking a shaft, and have already cut through the six-inch seam, expecting in due time to strike the more profitable 22-inch seam. At Rulo, some 15 or 20 miles below Aspinwall, near the south line of the State, a seam of coal has been wrought for some years. It is five inches thick at the outcrop, but, after a drift had been

[1] It is estimated to contain 3,000 square miles.

carried into the bank 100 feet or more, it increased to 11 inches, and then nearly disappeared again. About 200 bushels of rather inferior coal have been taken out of this mine; but it does not promise well. On the Indian Reservation, in Richardson County, this same bed has been worked, and several hundred bushels of coal taken out, but the mine was soon abandoned. This is probably the same as the 22-inch seam at Rulo. The fossils at both places are such as are common in the upper coal-measures. In Pawnee County, 35 miles west of the Missouri River, a thin seam of coal has been found. The coal is mostly used by blacksmiths in the vicinity, for there is not enough to supply the country with fuel.

At Tecumseh, the county seat of Johnson County, a thin seam of coal, varying from 10 to 15 inches in thickness, has been opened, and is now worked with some success. It is undoubtedly the same bed as that in Pawnee County, but it is not quite as thick or as good, as it contains large masses of sulphuret of iron, and other impurities. The cap-rock is a bed of limestone, not more than two or three feet in thickness.

The evidence against any important or workable bed of coal, within accessible distance of the surface, being found within the limits of Nebraska, increases in force continually. The fact that all efforts in searching for coal within the State, as well as in neighboring districts, have resulted in failures, renders the prospect very doubtful. Many excavations and numerous borings have been undertaken without success. At Omaha a boring of nearly 400 feet in depth was made by the Union Pacific Railroad, without passing any important seam of coal. At Nebraska City, a boring was made to nearly the same depth, with the same result.

As additional evidence from neighboring districts, Dr. Hayden mentions that at St. Joseph, Missouri, and at Leavenworth and Atchison, in Kansas, where the upper coal-measures are several hundred feet lower than at Omaha and Nebraska City, borings have been made from 300 to 500 feet with no success, and a shaft has been sunk at Leavenworth to a depth of 700 feet, resulting in the discovery of a bed of very impure coal three feet thick, quite unfit for use. (See page 492.)

Mr. Broadhead, a geologist attached to the Missouri State

Geological Survey, studied with a great deal of care a series of beds of the upper coal-measures in Northern Missouri, which he regarded as 2,000 feet in thickness, without finding a seam of coal more than two or 2½ feet in thickness.

In the valley of the Des Moines River, Iowa, 75 or 100 miles east of the Missouri River, coal-beds have been found by Dr. White, State geologist, varying from one to seven feet in thickness, but the rocks including those beds are regarded by him as of the age of the lower coal-measures. Indeed, the upper coal-measures of the West are regarded as the barren coal-measures, while all the workable beds of coal are confined to the lower coal-measures.

The conclusions at which Dr. Hayden arrives, or the result of his geological survey of Nebraska, and his solution of the problem as to whether there is any workable coal in the State, are, that the evidence is quite strong that Nebraska is unfortunately located on the western rim of the western coal-basin, and that no workable bed of coal will ever be found in the State, at a reasonable depth. He says it has been accurately determined that the rocks of the Carboniferous period occupy, as before described, only a small portion of Southeastern Nebraska, and that these rocks are of the age of the upper coal-measures, Permo-carboniferous, and barren of coal.

It is plain that all the carboniferous rocks of Nebraska pass beneath the more recent formations westward, to be disclosed again by the uplifting of the Rocky Mountain ranges. The carboniferous limestones are found all along the margins of the Rocky Mountains, on either side of the axes of elevation. On studying these fossils, we find that so many of them are identical with species found, in what are known to be the upper coal-measures, along the Missouri, that we do not hesitate to pronounce them as of the same age. Indeed, they are simply the western extension of them, thinning out, and gradually losing all the thin seams of coal and shale, and nearly all the beds of clay and loose sands, leaving for the most part massive beds of limestone. The coal-bearing strata are not simply buried beneath the upper, but they do not exist. That leaf of the volume of strata has been torn out.

While it is impossible, in a short article like this, he says,

to present all the details on which his conclusions are based, yet it seems more than probable that coal in paying quantities will never be found within the limits of the State of Nebraska. If this statement be true, it is a very important negative truth, not only to Nebraska, but also to very large portions of Iowa, Missouri, and Kansas. We already know that the carboniferous rocks do not exist in Dakota Territory at all, so that along the Missouri River there is a very large district of wonderful fertility, almost treeless, and destitute of fuel. This fact at once directs our attention to the lignite formations in the region of the Rocky Mountains.[1]

In corroboration of the unpromising picture which Prof. Hayden draws of the coal-deposits of Nebraska, the last United States census reports only 1,425 tons of coal as mined in that State in the year ending June, 1870, produced from three mines in Pawnee County, adjoining the Kansas line.

Here, then, just over the Missouri River, we see the last of the good old carboniferous coal-formation, which we have traced from Mauch Chunk and Towanda in the east to Omaha and Fort Riley in the west, and which in its better developments produces the most magnificent of all fuel. The fertile soil of our country is unquestionably the most important of our geological formations. But, next to this, the most valuable of our natural resources are the productions of our coal-fields. We therefore cannot but experience a feeling of regret to see how in going westward our coal has gradually deteriorated in quality, and its beds dwindled to insignificance, until they finally disappear.

[1] For the full details, of which the foregoing is a summary, *see* "Final Report of United States Geological Survey of Nebraska," etc., by F. V. Hayden, Executive Document 19, House of Representatives, First Session, Forty-second Congress. Reprinted 1872.

XXIII.

MISSOURI.

In addition to the extraordinary isolated deposits or masses of coal in the region near the mouth of the Osage River, which will be hereafter described, there is a very extensive deposit of coal of the usual character of that found in the Western States, which covers the whole of the northern and northwestern part of the State of Missouri. To get a general idea of the area covered by the carboniferous rocks, a line might be drawn from the northeastern corner of Marion County, on the Mississippi River, in the northeastern part of the State, to the middle of the western boundary of Jasper County, adjoining the southeastern corner of Kansas, in the southwest part of Missouri. The older rocks come to the surface, it is true, in many places on the northwest side of this line, as in the valleys of the Mississippi and Salt Rivers, but, on the other hand, there is quite as much coal territory southwest of this line, in St. Louis, St. Charles, Montgomery, Audrain and Ralls Counties, as is wanting northwest of it. Prof. Swallow thinks it is safe to estimate the area covered by the coal-measures in the State equal to all on the northwest of the boundary indicated above, which will give 26,887 square miles of coal-beds. The southeastern outcrop of the coal-measures runs from the mouth of the Des Moines River, through the counties of Clark, Lewis, Marion, Monroe, Audrain, Boone, Cooper, Pettis, Henry, St. Clair, Cedar, Barton, and Jasper.

The census of 1870 reports the production of coal in Missouri for that year at 621,930 tons. Workable beds of coal exist in nearly all places where the coal-measures are developed in Missouri, as some of the best beds are near the base, and

must crop out on the borders of the coal-field. All the little outliers along the borders contain more or less coal, though the strata are not more than 10 or 15 feet thick.

The older formations which have been observed in Missouri are the Potsdam sandstone, calciferous sand-rock, Black River and Birdseye limestone, Trenton limestone, Utica slate, Hudson River group, Niagara, Lower Helderberg group, Upper Helderberg, Hamilton, Chemung, mountain limestone, and the coal-measures.

The coal-measures are divided by Prof. Swallow into the upper coal-series, 300 feet thick; the middle, 200 feet, and the lower coal-series, 150 feet thick—in all 650 feet; but on the line of the Hannibal & St. Joseph Railroad the coal-measures are 739 feet thick. This is in addition to the mountain or carboniferous limestone, which is subdivided into four well-characterized divisions, consisting of the ferruginous sandstone, from five to 200 feet; the St. Louis limestone, about 250 feet thick; Archimedes limestone, from 50 to 200 feet, and the encrinital limestone, which is from 175 to 500 feet.

At the date of Prof. Swallow's second report, in 1854, thin strata of coal six inches thick had been discovered in the upper coal-series, but no bed of sufficient thickness for working.

The middle coal-series contains a seam of bituminous coal of excellent quality, two feet thick. This is the bed worked at Wellington, Lexington, near Dover Landing, and at various points between those localities, on the Missouri River. There are also two other permanent seams, each six inches thick, besides thin beds of that mineral found in the various strata of bituminous shale.

The lower coal-series of Missouri, like that of Iowa, is the most important and productive. In the elaborate sections given by Prof. Swallow, the coal-seams in the lower series are: No. 62, one foot of coal; No. 64, only four feet below it, which is six feet thick at the mouth of La Mine, but contains some sulphuret of iron; on the Hinkston it is only three feet thick, but of an excellent quality; while in St. Louis County its thickness is much less. In some places it thins out entirely, and is replaced by shale. No. 68 is one and a half foot of coal, and is worked in Cooper, Boone, and Howard Counties. No.

70 is one-half foot of coal, but is not constant; and No. 72 is one foot of coal.

The beds of the lower coal-series are well developed in Cooper County and in Boone. They are also met with in Marion, Monroe, Pike, Clark, Lewis, Shelby, Audrain, Callaway, St. Charles, St. Louis, Howard, Saline, Henry, St. Clair, Bates, and Jasper, being the counties along the line of outcrop, and they underlie the upper coal-rocks in nearly all the counties northwest of these. The strata of this series are very irregular in their thickness and lithological characters. The coal-beds can only be identified by their position relative to the hydraulic limestone No. 66, which is the only sure guide in exploring this part of the coal-measures. The coal-beds 62 and 64 appear to be wanting in many places.

The coal in St. Louis County comes from one or more of the lower beds. The coal-measures here occupy the territory between the Mississippi and Missouri Rivers, north of the city of St. Louis, or 160 square miles, and its vicinity to so large a place makes it very important. Here the lower coal-measures occur under a micaceous sandstone. The coal-seam that is worked varies from two to five feet in thickness, and is nearly horizontal. The shafts are only from 30 to 40 feet deep. At Gartsides mines, the coal consists of several layers, with thin partings of clay and iron pyrites interstratified, in all, five feet. The average thickness of workable coal is about three feet six inches. Sometimes it dwindles down very suddenly to two feet, for a few yards, and then as suddenly attains its usual thickness again. At Russell's mines, the coal varies from four to five feet in thickness. Hunt & McDonald's mines are the most extensive. Their shafts are from 22 to 38 feet in depth, and the coal from three to six feet thick. At Morrow & McGregor's coal-mines the bed of workable coal is about three and a half feet thick. Numerous other mines might be mentioned of the same general character. It is pretty evident that there is an 18-inch seam below, and an eight-inch seam above the main workable bed in St. Louis County, making, in all, three seams below the ferruginous sandstone. The distance to the city is so short that large quantities of coal are hauled in wagons to St. Louis, and the county produced 444,642 tons in

1869–'70. This is a detached portion of the Illinois coal-field which occurs in St. Louis and St. Charles Counties.

On the line of the Hannibal & St. Joseph Railroad, Mr. Hawn, one of Prof. Swallow's assistants, reports seven seams of coal. His section is numbered differently from the one already given. His coal No. 24 is found at Utica, cropping out in the cliffs, and is 14 to 20 inches in thickness, of good quality, and is also found in many other localities. Coal No. 38 is two feet thick, and is similar to 49, hereinafter described. No. 45 is coal six inches thick. No. 49 is the most important coal-bed on this line or district. At B. Powell's it is six feet thick, including a six-inch stratum of clay, and has a fine, laminated structure, with a dull-black charcoal color and appearance. It is very light, burns freely, and contains but little pyrites. Its lightness indicates that it would produce but a small proportion of ash or residuum. Its freedom from sulphuret of iron renders it a valuable coal for steamboats and smiths. No. 55 is coal three feet, E. S. Gibson's, and is an inferior article of coal, containing too much sulphuret of iron. No. 60 is a two-feet seam of coal; and No. 67 is another of the same size, being the Lick Creek coal.

In 1868 the supply of coal for St. Joseph was wholly from the mines of the Central Coal & Mining Company at Bevier, 131 miles east of St. Joseph, on the Hannibal & St. Joseph Railroad, and five miles west of Macon City, where it is intersected by the Northern Missouri Railroad. There were also mines owned by the same parties three miles east of Macon City, also in Macon County. The coal is very similar in quality, apparently, to that mined at Moingone, five miles east of Boone, Iowa, and taken to Omaha by the Northwest Railroad. It is used in the locomotives on the Council Bluffs & St. Louis Railroad, and seems to be rather less sulphurous than the La Salle and Wilmington coals, that go to Chicago. It is the only fuel used at St. Joseph, except wood, and is also used for blacksmithing, making a very hot fire, but it consumes very rapidly. It is mined in shafts 90 to 100 feet deep. It was retailed at St. Joseph at 30 cents per bushel, and had been sold as high as 50 cents per bushel. Macon County produced 75,282 tons of coal in 1869–'70, by the census reports. No coal is

mined between St. Joseph and Omaha. Southward, along the Missouri River, coal is mined at Lexington, Lafayette County, and at Richmond.

Inferior as these Missouri coals are in quality to those of Pennsylvania, they are invaluable on these fertile, treeless prairies and rich river-flats, where there is no other fuel.

The Osage Coal-Region of Missouri.

There have been found in Missouri a number of very singular local deposits of coal of limited extent, but of remarkable thickness. They have not the usual form of coal beds or seams, and are not associated with the proper rocks among which, according to all rules and precedents of geologists, and all experience elsewhere, coal should be expected, but they occur in ravines or valleys of denudation in the older rocks below the level of the regular seams of coal.

Prof. Meek, in describing some of them in the State geological reports, observes, that "most observing persons who have frequented coal-regions are aware of the fact that coal-beds which crop out in valleys, and along slopes where there are no considerable disturbances of the strata, usually extend horizontally beneath large areas of country. General, however, as this law is, it is by no means applicable to this region; for, instead of being spread out in continuous beds, as is usually the case, these deposits of coal are found in widely-separated masses which, although of great thickness, are always very limited in their horizontal extent, being in every instance confined to shallow depressions in the lower Carboniferous, and even lower Silurian rocks. It is manifest that these depressions must have been worn in the older rocks previous to the deposition of the coal-measures, though in many instances they appear to have been subsequently widened and deepened in such a manner as to partly undermine the coal, and cause it to fall or slide from its original horizontal position."

These local abnormal deposits of cannel and common bituminous varieties furnish some of the best coal in the State; they are of great value for supplying the local demand, and some of the beds of cannel varieties could furnish a very large supply of an excellent article for gas and those manufacturing

purposes where a light, pure coal, producing an abundance of flame, is desirable.

Owen, in his geology of Wisconsin, Iowa, and Minnesota, speaks of these immense beds of coal, which, he says, attain a thickness of 20 and perhaps 40 feet, and which lie near the mouth of the Osage River, on both sides of the Missouri. An analysis by Johnson, of this Osage coal, gave, moisture expelled, at 230°, 1.67; other volatile matter, 41.83; fixed carbon, 51.16; and ashes, 5.34; and less than half of one per cent. of sulphur. It is remarkable, not alone for its extraordinary thickness, but also for the peculiar character and structure of the coal itself, together with the mineral insinuations which invade it. The lightness of this combustible is such that, before imbibing water, it will float upon that fluid, indicating a specific gravity actually less than 1. In its structure, fracture, and lustre, it has an appearance intermediate between cannel-coal and the dull varieties of asphaltum; but it contains 31 per cent. less volatile gases than pure bitumen, and from 5 to 10 per cent. more volatile matter than the ordinary varieties of the bituminous coal of the Western coal-fields.

At the pit west of Marion, Owen further says, this coal assumes a cuboidal and even a subcolumnar structure, somewhat analogous in miniature to basaltic trap, while at the same time a net-work of pyritous ores of zinc and iron has ramified its joints and fissures, appearing often in brilliant crystalline forms, the whole bearing evidence of great local disturbance, igneous action, and gradual consolidation under heavy pressure.

Prof. Owen gives the following further explanation of this singular formation: It appears altogether probable, from the peculiar character of its coal, its structure, and great local thickness, that it has been subjected to a sufficient degree of heat to have fused or semi-fused the mass, under a pressure that prevented the escape of the volatile gases, transferring it at the same time, either in this condition, or by sublimation, from its original bed into some wide, adjacent fissure, formed by disrupture of the strata, when it has then very gradually passed into the solid state. Its uniform occurrence, in close proximity to an abrupt change in the geological formation of the adjacent country, and the sudden elevation of the rocks lying below the

Carboniferous, together with the highly-inclined position of the coal itself, furnish abundant proof that it has been implicated in the remarkable disturbances which have convulsed the whole of the surrounding country subsequent to the Carboniferous era.

East of this peculiar Osage coal-region, the limestones of the Carboniferous epoch are invaded from beneath by the great uplift of magnesian limestone which bounds for some distance on the southeast both the Missouri and Iowa coal-fields, and becomes in a measure confounded with them. This mixed formation composes those high mural escarpments near the mouth of the Gasconade, and at Tavern Rock, which attain at the latter locality an elevation of over 300 feet. This great axis separates the outcrops of coal of the Osage region in Cole, Callaway, and adjoining counties, from the coal-pits in St. Louis County, by a zone gradually widening, as it approaches the Mississippi River, to nearly 100 miles. Along this portion of the Missouri Valley, it is only on the summits of the highest ridges that any rocks can be found referable to the Carboniferous period.

Prof. Swallow, in his second report, refers these important deposits of coal to the regular coal-measures with some degree of hesitation, as he had then found no positive evidence of their true geological position. The extensive country to the east being destitute of coal, caused by its upheaval, and its being here found in ravines in unusual bodies, recall to our minds the inundations which have sometimes occurred of semi-fluid peat saturated with water when lying on a sloping surface.

The region where these isolated bodies of coal are very common is exactly in the centre of the State, consisting of five adjoining counties, viz., Cooper, Moniteau, and Cole, on the south bank of the Missouri River, extending from the mouth of the Osage River west; Morgan County, which is also north of the Osage River and south of Cooper and Moniteau; and Callaway County, on the north side of the Missouri, opposite the mouth of the Osage River. The production of these counties, as reported by the census of 1870, was 7,807 tons.

It would be tedious and quite unnecessary to refer to more than a few examples of these extraordinary deposits of coal, especially as many of them will not yield sufficient quantities for

exportation. In Cooper County, Staples's coal-bed, in a ravine of carboniferous or Archimedes limestone, has first six feet of good cannel-coal in regular strata, and, immediately below this, 20 feet of very good common bituminous coal. It dips to the south at an angle of 15 or 20°, is covered with six feet of soil and local drift, and is a very valuable bed of the very best coal, but its character is such that the quantity cannot be determined until it is worked out. Paxton's bed is four feet thick, also an irregular deposit in a ravine of encrinital limestone; and quite a number of others in this county are described of thicknesses of six, seven, eight, and even 12 feet.

Drafton's coal-bed is at least 18 feet thick, it has been worked in an open pit to the depth of 16 feet, and is in a ravine in the Chemung group.

In Moniteau County other beds are described, existing under circumstances in all respects like those already mentioned. Among others, Mr. Meek describes Robinson's, in a ravine in the encrinital limestone, as appearing to average about eight feet thick, but it varies much in thickness, in consequence of the irregularity of the floor upon which it rests consisting of chert, such as covers the surrounding hills. It does not, however, look as though originally deposited upon this floor, but is everywhere crushed and distorted near the chert, as if the latter had been violently forced up into it by some power acting from beneath, so that the coal appears to be much fractured, and often presents those peculiar, polished surfaces, frequently seen in rocks which have been subjected to some kind of motion among themselves while under powerful pressure. There can be no doubt, Mr. Meek says, that this coal has slidden down from a higher position in consequence of some undermining process connected with the denudation of the country.

The foregoing are given as examples of these singular masses of coal, which appear to be very common in ravines below the coal-measures in this Osage region. There is a famous bed of this kind in Callaway County, which is said to be over 80 feet thick, and many others are reported, varying in thickness from one to 36 feet.

These very remarkable deposits of coal and shales are made up of beds of cannel and common bituminous coal, the same

bed often containing both varieties, and a few unimportant strata of shales, which, however, are very thin. They are found in ravines and cavities of denudation, in the rocks of all ages, from the Archimedes limestone down to the calciferous sand-rock. All the cannel-coal observed in the State of Missouri belongs to these irregular deposits. They also contain bituminous coal of the very best quality, as well as varieties of various shades between the two. When one variety rests upon another, the change is sometimes gradual, but usually the transition is very abrupt, a mere line separating them.

These Missouri[1] and Osage River coal-pockets must be regarded as among the curiosities of our subject, and, as the exception proves the rule, we can see how great is the general regularity and uniformity of coal-seams as to their thickness, persistence, and place in the geological series, from the surprise that is expressed at these masses of coal displaced by some unknown cause, found in unusual forms, and reposing in the wrong bed, being circumstances almost without a parallel.

[1] *See* Supplement on page 678.

XXIV.

KANSAS.[1]

The accounts already given of the coal-fields of Iowa and Missouri should first be read, in order to a proper understanding of that of Kansas, which is simply a continuation of the formation which covers the northern part of Missouri, and the southern part of Iowa. It also, according to Prof. Swallow, occupies a part of the Indian Territory south of Kansas.

The lowest geological formation known in Kansas is the upper portion of the coal-measures. This is an important leading fact, which it is necessary to bear in mind as the key to the geology of this State, and that of the whole country west of Kansas; taken in connection with the other important feature that the dip of the strata is toward the northwest, passing at a low angle of inclination under the Permian, Triassic and other later stratifications. In all the States east of Kansas, the coal-measures, where they are found, are geologically the highest rocks, and the end of our geological series. It is true, we have the later Triassic red sandstone belt of New Jersey, Pennsylvania, Virginia, and North Carolina, but that is only the filling up of a sunken gulf left after the elevation of the Alleghany Mountains, and we have the still later additions around the margin of the continent, much of it of a mere earthy or sandy nature without solid rocks, the cretaceous and tertiary shores of the Atlantic and of the Gulf of Mexico extending up the Mississippi Valley.

But, with these exceptions, the United States east of the Missouri River became dry land after the coal-measures were

[1] Compiled from the Geological Report of B. F. Mudge, for 1864, and that of Prof. G. C. Swallow, published in 1866.

completed; they have had no more recent additions to their rock formations, and, in searching for coal in all these States, we pass over the older Silurian and Devonian rocks up to the Carboniferous, the highest of all. As yet, no Permian fossils, or those of the next higher formation, have been found in any part of the United States east of Kansas; but, in this State, this formation, the next step upward in the geological series, is found, covering up the coal-measures and burying its fuel treasures too deep for mining purposes. In the eastern part of the State of Kansas, however, the coal-measures are found.

Area and Boundaries.—The fossils of this epoch are found over all the State east of Fort Riley, which is in Davis County, at the mouth of the Republican Fork of the Kansas River, embracing about one-third of the State. The line which separates the coal-measures from the Permian runs rather irregularly in a northeasterly and southwesterly direction. Considering Fort Riley as on the line of average extent westerly, we shall have the territory of the coal-lands 107 miles in average breadth from east to west, and 208 miles, the width of the State, from north to south; which gives an area of 22,256 square miles. Prof. Swallow in 1866 made the area 17,000 square miles. This includes only the coal-measures proper, and not the Permian, although the latter belongs to the Carboniferous age. The coal-measures in the settled part of the United States are estimated to cover 192,000 square miles. It will thus appear that Kansas contains less than one-eleventh part of all the coal-lands of the United States; we do not, however, intend to be understood that the State contains one-eleventh part of the coal, for Pennsylvania has more numerous and thicker working beds. But we shall hereafter show that we have one seam which, for all practical purposes, is inexhaustible. The question of the area of distribution becomes more important than the quantity to each square mile, when the latter is sufficient for all our wants.

Structure.—The coal-measures here have undergone little change, and lie nearly in their natural position; they dip, on the average, as before stated, slightly to the northwest. In some parts of the State this inclination cannot be seen, and in some instances there is an anticlinal ridge or dip, in the oppo-

site direction. Thus, in Wyandotte County, the strata are nearly level, or have a slight inclination to the southeast. This may be seen by tracing any bed of limestone 10 or 15 miles. The peculiar shale, which is numbered 22 in our section, is seen at the water's edge, at Parkville, on the Missouri River; but 12 miles westerly, near the State Penitentiary, at Leavenworth and at Atchison, it is higher. Most of Jefferson, Leavenworth, Atchison, and the southern part of Doniphan Counties, show little variation from a level, and that little is an inclination to the southeast.

Among the greatest angles of dip which we have noticed, is one extending from Lawrence to Lecompton, where, in a distance of 10 miles, it is over 100 feet. It will be seen that this small disturbance of the strata is very favorable to the opening of coal-shafts. No "faults" will be found in the beds, and the probability of reaching the coal at reliable depths, at any given point, will be nearly certain. It also gives us a larger area of the coal-field, as a higher angle of inclination would soon carry the beds too deep for mining. This portion of the State also shows a great uniformity in the thickness of the strata. About one-fourth of the whole quantity of the deposit is limestone. South of the Kansas River, the strata show increase of thickness, particularly in the shales, accompanied with a slight increase of dip. This increase of thickness is very marked in Miami County, as developed by the oil and salt borings.

It is well understood that the extreme upper portion of the coal-measures does not contain coal of first quality, or seams of much thickness. Those peculiar favorable conditions of climate, etc., which were so important for the accumulation of a vast amount of vegetable matter, had begun to change, so that the coal was small in quantity and poor in quality. A fine illustration of this passing away of the peculiarities of the vegetation of the coal period is to be seen in the banks of the Neosho, about three miles below Council Grove. It consists of a stratum of shale, two feet in thickness, full of the remains of the vegetation of the period, but accompanied by a singular commingling of the material with other substances; and the vegetation shows less of the transformation from its original state than that of the true coal-beds.

A marked peculiarity of our coal-seams is, that while the remains of plants are abundantly visible in almost every coal-stratum, few passably perfect specimens can be obtained. Nor do the shales, above and below the coal, furnish us with any better. Enough can be seen to give the general characteristics of the plants, but scarcely ever can any be found which will designate the species, and, consequently, sufficiently perfect to deserve a place in a cabinet. We have already learned, from Profs. Hall and White's excellent reports as to the coal-measures of Iowa, that only the lower portion of these coal-measures affords good workable coal-seams, which in Iowa dip to the southwest, being deeply covered, in Southwestern Iowa, by the upper coal-measures, containing there only very thin seams of coal. These barren upper coal-measures extend across Northwestern Missouri and Southeastern Nebraska. We are, therefore, prepared to find the same state of things in Northeastern Kansas. The particulars which Prof. Mudge reports, in regard to his examinations of this part of the State, fully realize this expectation. He discovered in all this part of the State only thin seams of coal, of but little over one foot thick, and of a poor quality.

But, as the dip in Kansas is toward the northwest, we would be encouraged to look up the dip toward the southeastern part of the State for a thinner part of the measures, corresponding with the exposures in Iowa along the Des Moines River, being the southeastern or Kansas border of this great coal-basin, as the Des Moines is its northeastern. The details hereafter given from Prof. Mudge's report of the two larger underlying seams of coal found in Linn, Bourbon, and Cherokee Counties, in the southeastern corner of the State, seem to prove this to be the structure of the coal-field, that this is the section of the State where the valuable coal-seams, or those of workable size, are accessible, and that they dip toward the northwest about three feet per mile.

Coal-Seams—their Distribution.—In a State where, to a great extent, prairie covers the surface of the country, the question of fuel becomes of the first importance. Not only is a cheap and abundant supply material for domestic purposes, but it is equally necessary to drive the steam-engine, for the

manufacture of the hundreds of articles in daily use. In this respect Kansas is amply supplied. In almost every settled county, coal, of varied quality, is found near the surface; and, as we have already shown, the coal-measures, with good workable seams, underlie the eastern portion of the State. As much of our coal-field is the cropping of the upper measures, it follows that most of the surface-coal, in all but the southeastern part of the State, will lie in thin seams, and be of an inferior quality. A notice of the surface-coal, as it is found in various places, will illustrate this subject. In Republic County, on the north line of the State, the highest geologically, being above the true coal-measures, we find the lignite variety. The thickest seam which came under our observation measured 28 inches, but the middle portion was much mingled with a clay-shale, and the upper parts, though burning readily, proved an inferior article, yielding a bad sulphurous odor, and much ashes. We saw the same vein at several points in that county, but it showed less thickness, with no increase of quality. Similar coal crops out easterly of this, in Marshall and Nemaha Counties, lying east of Republic, but usually of less thickness. Coal has been mined at various points in Brown and Doniphan Counties, in the northeast corner of Kansas, but seldom over 12 inches in thickness where seen by us. It was a little better in quality than in Republic County, but still usually an inferior article. It was of light body, and contained too much sulphur to be suitable for smith-work. At Jordan's farm, 12 miles west of Atchison, next south of Doniphan County, it is mined in a seam of only 10 inches in thickness. The then high price of fuel alone could have justified the waste of labor on so thin a seam. At other places in that county, the same vein crops out somewhat thicker than at Jordan's mine. In Jefferson County, next south of Atchison, near Grasshopper Falls, and at several other places, coal has been obtained, but in no place seen by us was the seam over 15 inches in thickness. In Leavenworth County, on the Missouri River, the "Stranger coal" has been mined to a considerable extent, and, owing to the great demand for fuel, has found a ready market. The seam, when first opened on the Big Stranger, 12 miles from Leavenworth, was about three

feet in thickness. The middle of the vein was much mingled with shale, the top and bottom being a passable quality of coal, somewhat sulphurous. In drifting into the hill a few hundred feet, it diminished in quality and quantity, and the mine is now abandoned. Three miles distant, on the Little Stranger, several openings have been made, but the coal is not usually over 16 inches in thickness. The same seam appeared at the surface in several places in Wyandotte County, the next south of Leavenworth, on the Missouri River. Many other places where it is found might be mentioned, lying north of the Kansas River, but these are sufficient to show the general character and thickness of the surface-coal. We have seen none in that part of the State which we should consider a first-class article, or which we thought suitable for working iron. As it usually burns freely, and the cities furnish a ready market at high prices, it has been mined with profit.

South of the Kansas River, in the middle and western portions now settled, the coal is much of the same character. In Wabaunsee County, no seam was seen by us over 10 inches, and only worked occasionally by some blacksmith, who could obtain no better fuel. In Shawnee County, near Topeka, coal is obtained in numerous places, by stripping off the overlying soil from one to three feet in thickness, where the coal is from 12 to 16 inches. In the vicinity of Lawrence, in Douglas, the next county east, a similar seam has been worked. South of Lawrence, in Franklin County, on the Sac and Fox Reservation, 15 miles southest of Pottawattomie City, a seam is found 15 to 18 inches, and has been worked. A portion of it is of a very good quality. The seam appears in various places toward Scott Creek, and near the latter place, in the fall of 1863, caught fire and burned for several weeks. At numerous places in Osage County, coal has been mined of a better character than is usually found in the surface-beds. The variable character of the seam in the vicinity of Burlingame shows the peculiarities of the coal in the upper portion of the coal-measures, though the quality averages better than we usually find in other parts of the State, at the same geological altitude. At Dragon Creek, the vein is 18 inches thick. Two miles north, where it is worked on Mr. Marple's farm, in an horizontal

drift, 300 feet long, it varies from 20 to 28 inches. On the farm of Mrs. Morrill, one mile farther, it is but 18 inches, and, at Judge Rock's mine on the adjoining farm, it is also but 18. This coal is of very fair quality, and the selected portions free from sulphur.

Coal has been seen by us in numerous other places, in various counties, but enough has been narrated to show the characteristics of the thin seams in the upper verge of the coal-measures. The quality is seldom good, and the varying thickness of the veins always renders the prospect of mining uncertain. Such variations, sometimes amounting to one-half, are not seen in the thick beds found near the centre of the coal-formation. The variable quality is even more remarkable than its varying quantity. A seam of coal, to furnish a cheap article, at fair profits, should be nearly three feet in thickness.

Lower Coal-Seams.

There are two seams of coal, in our State, which combine a uniformity in quality and thickness over all those mentioned. The first is seen cropping out on the banks of the Little Osage, in Lynn and Bourbon Counties, in the southeast part of the State, near the Kansas and Missouri State line, and thence in various places in a southwesterly direction across the State, into the Indian Territory. It also crosses Missouri in a northeasterly direction, and is mined at Lexington, on the Missouri River. It is a good article of bituminous coal, better on the average than the other seams described. Above the strata of coal is about two feet of shale, which is overlaid by a bed of hard limestone, that affords an excellent roofing for the mine. The other, and in all respects the most important coal-bed, crops out in the centre of Cherokee County, crossing Cow Creek, near its principal forks, and thence running at the surface in a southwesterly direction across the State into the Indian Territory. It measures, in several places where it has been slightly worked, five feet six inches to six feet nine inches in thickness, and averages about six feet. The bed extends in a northeasterly direction across Missouri, to the northern part of the State. The seam is the same that is wrought at Boonville, Missouri, and near Hudson, on the Chariton, and at both

places is about six feet in thickness. In this State, as in most places in Missouri, it is of excellent quality. In Cherokee County it appears in the open prairie, where there is but little overlying soil. This is first removed, and the mining is in the open air. Where it is so deep beneath the surface as to require drifting, it is overlaid by shale sufficiently hard to afford a fair roofing. The last two seams are the best in quality, and most persistent in thickness and uniformity of character, of any in the State. These, with all the strata of the coal-formation in Kansas, dip on an average of about three feet to the mile toward the northwest, and are seen as far west as Manhattan and Fort Riley, where they disappear under the more recent formations.

Consequently, these coal-seams underlie the whole of the eastern part of the State to that extent. In fact, every geological indication shows that they lie conformably, farther west, in a position nearer to the surface than many of the coal-beds in England, which are there wrought to supply that country with fuel. These two seams, we hesitate not to say, will hereafter supply the State with coal, to the neglect of all others; and perhaps the Osage seam will be ultimately disregarded, and only the thick Cherokee bed worked. They are but a little over 100 feet apart, in a vertical position; and, when once a shaft from the surface has penetrated the strata to the former, the economical inducements will be strong to go an additional 100 feet to the latter, and work in a bed of coal six feet in thickness instead of one half as much. The advantage of working in a thick seam, instead of one that is thin, is very apparent. The objections to deep mining after the shaft is once opened are more apparent than real. A man can work as comfortably 300 feet below the surface as at 30. The cost of raising the coal 300 or 500 feet is very small on each ton. The greatest apparent objection is the trouble which may occur from the influx of water. This, however, is not so great as in many other States. About one-fourth of the total thickness is limestone, and other three-fourths are shales. The great proportion of the latter is composed of clay, which does not allow water to penetrate freely. Those who have been obliged to dig deep wells in Kansas know how slowly the water percolates these blue

shales, and how moderate is the supply in artesian borings. This feature, which is objectionable in wells, is favorable in mining.

The preliminary report of the Geological Survey of Kansas, by Prof. G. C. Swallow, published in 1866, furnishes the following additional particulars in regard to the coal-field of this State. The boundary between the Permian and Carboniferous formations crosses the State in an irregular line from a point near the 96th parallel, in Nemaha County, thence near Manhattan, in Riley County, and Emporia, in Lyon County, and thence south across the head-waters of the Verdigris, in Greenwood County, and Fall River. They cover the surface over an area of 17,000 square miles, and then run beneath the Permian rocks westward. The coal-measures are made up of more than 80 different seams of limestones, with great similarity in their fossils and appearance, separated by numerous sandstone shales and marls, fire-clay, and coal-seams. These strata lie in a nearly horizontal position, with numerous undulations and slight general dip to the west, showing no signs of local disturbances, save in a few localities. The lowest of these strata come to the surface in the southeast, and, as the country rises to the northwest, the higher beds successively crop out, resting upon those below until they reach a thickness of 2,000 feet, as measured along the outcropping edges. Nearly all the beds of limestone, sandstone, and sandy shales, as well as the coal-beds, are thicker toward the south and east. But the most important irregularity observed is the want of persistence or continuity in the coal-beds. As a general rule the coal-seams in this State are more persistent in the southeastern portion of the State than farther northwest, and the lower beds more so than the upper ones. This is one of the reasons why the coal is so abundant, and can be mined with so much certainty along the eastern outcrops of the lower bed, extending from Fort Gibson to Forts Scott and Smith, and thence across the Osage through Bates, Johnson, and Saline Counties, in Missouri, and through Boone, Howard, Randolph, and up the Chariton Valley into Iowa. Everywhere along this line shafts can be sunk upon the lower coal-beds with an almost absolute certainty of success. But, farther west, and along the outcrop of the upper beds, mining

operations must be more precarious; for, while the geologist can tell where the rocks containing each coal-bed can be found, and at what depth, yet this irregularity or want of persistence renders it somewhat uncertain whether the coal will be found in its usual place.

The elaborate section given by Prof. Swallow shows 22 different seams of coal varying from a few inches to seven feet in thickness. Ten of them are over one foot in thickness. The total thickness of the coal-measures in Southern Kansas is 2,000 feet, and they are covered by the very best soils in the State.

Coal-beds crop out, according to Prof. Swallow's report, in the following 20 counties, all of which are on the eastern borders of the State, and none of them, except Greenwood and Wabaunsee, are west of the first three eastern tiers of counties, viz., Brown, Nemaha, Doniphan, Atchison, Jackson, Leavenworth, Wabaunsee, Shawnee, Douglas, Miami, Franklin, Osage, Coffee, Linn, Bourbon, Allen, Woodson, Greenwood, Neosho, and Cherokee, and perhaps others. At Oswego, in Labette County, coal is also mined, and in Montgomery County.

Besides, it will be recollected that these coal-measures extend westward beneath the Permian rocks to an unknown extent. Probably, throughout the entire central and western portions of the State, some at least of the coal-beds extend under these regions, and there will be no more difficulty in raising this coal than has been overcome in many of the most productive mines in England and other parts of Europe.

The quality of a large part of the Kansas coal is good. Some of the most important beds are very free from sulphur and other impurities. They cake and coke well, and will be valuable for gas-manufacturing purposes.

Brown County, near the northeast corner of the State, has three seams of coal. The upper one ranges from 14 inches to 2½ feet thick on Roy's Creek, where it has furnished coal for the surrounding country since the first settlement. The bed has a great lateral range, and is the equivalent of the Burlingame bed in Osage County.

The next bed is 50 to 100 feet below the first, in the vertical range. On Wolf River it is three feet thick, and of good quality. This is also extensively distributed over the country.

The next bed is some 200 feet below the above, and is the equivalent of the Topeka bed. This bed is worked above Yankton, where it is some 20 inches thick, and of excellent quality.

These beds, though thin, will afford an ample domestic supply of coal for all time to come. Such beds are not appreciated, the unpractised believing that they cannot be mined. This is an error, for, after an entry or gangway is formed on an outcrop of 1½ foot, a practical miner will deliver 30 bushels of coal *per diem*, at its mouth, with ease.

In *Doniphan County* the two lower beds in Brown County should also be found. In consequence of the great depth of the bluff formation, but few outcrops occur.

Miami County is near the centre of the eastern boundary of Kansas. The only coal in this county, that can be worked, is from 13 to 33 inches thick, the seam being of the latter size on John Ross's land, on Sugar Creek. It is also exposed on Sugar Creek, nine miles south of the Linn County line. It is of a medium quality, rich in gas, cokes well, and burns with a clear flame, but contains some sulphuret of iron and other impurities. It could be worked in shafts in any part of Miami County.

In *Osage County* there is one workable bed of coal, which crops out near Burlingame, where it is extensively mined, and furnishes coal for the country for some distance around. It is composed of compact parallel plates, with a semi-conchoidal fracture, and when first mined it has a lustrous brown color, shading into black. It burns freely, and, when free from pyrites, is an excellent coal. The seam varies from 18 to 28 inches in thickness.

Lyon County.—The rocks of this county belong to two different ages, the Permian and Carboniferous. Their limits may be nearly determined by drawing a line through the county from the northeast corner to the southeast, and assigning the southwest half to the Permian, and the northeast to the Carboniferous.

In *Greenwood County* several beds of coal are found in the valley of the Verdigris. They have been seen submerged in the beds of streams, but their size and quality have not been ascertained.

In *Montgomery County*, on the south border of the State, the coal-field is known to embrace about 150 square miles. The coal lies from three to 100 feet below the surface; it varies in thickness from 12 to 39 inches, and the quality is excellent, equal to any in the State. The coal at Thayer, in Neosho County, is of very superior quality, but of less extent than that in Montgomery County. No coal has been found in Howard, or the counties west of it, nor in the valley of the Verdigris, north of Montgomery, that will repay working. The counties of Bourbon and Cherokee have quite extensive coal-fields, with about the same thickness of seam and distance below the surface as in Montgomery. The thickest seam in the latter county is three-fourths of a mile south of Independence, which measures from 30 to 39 inches in thickness, and can be worked at from five to seven cents per bushel. As to whether there is a lower seam is still an open question, as no test has been made.

It will be noticed that the best portion of the Kansas coal-field adjoins the Indian Territory; and doubtless it extends into that unknown country, which, in addition to its deposits of fuel, is said to be, in other respects, one of the finest portions of the United States.

Prof. Swallow gives an elaborate section of the carboniferous rocks of Eastern and Southern Kansas, but it contains so little of economical value, that the following summary of it, in descending order, will be sufficient for the general reader:

1. *Upper Coal-Measures*, 391 feet thick, consisting of 56 layers of marls, limestones, shales, and sandstones, including three thin seams of coal, measuring, respectively, one to three inches, and four to ten inches.

2. *The Chocolate Limestone Series*, 79 feet thick, in 10 layers, with no coal-seams. The rocks, like all that follow, are limestones, shales, and sandstones.

3. *The Stanton Limestone Series*, 74 feet thick, in five layers, with a seam of bituminous coal, the Marais des Cygnes and Verdigris bed, from one foot to two feet six inches.

4. *Cave Rock Series*, 75 feet; consisting of the Cave limestone, 25 feet, and the Einstein sandstone, 50 feet.

5. *Spring Rock Series*, 88 feet thick, in nine layers, with two seams of coal, one of them four to eight inches, in Miami

County; and the other 46 feet lower, six inches to one foot six inches; its locality being west of Baptist Mission, west of Topeka.

6. *Well Rock Series*, 238 feet thick, in 11 layers, containing a coal-seam from one to five inches, at Centre Creek, west of Lawrence.

7. *Marais des Cygnes Coal Series*, 303 feet thick, in 25 layers, with four seams of coal measuring respectively two inches; one foot eight inches to two feet nine inches, in Linn County; one foot to two feet six inches at Marais des Cygnes; and two to three feet at the same locality, and at Mound City.

8. *Pawnee Limestone Series*, 112 feet thick, in nine layers, containing six inches of coal and coal-smut above Fort Scott.

9. *Fort Scott Series*, 142 feet thick, in 12 layers, with two seams of coal, one of them six inches, and the other one foot four inches, at Little Osage, Fort Scott, and south to Drywood and Bone Creek, and west to Neosho.

10. *Fort Scott Marble Series*, 23 feet thick, in seven layers, with a seam of good coal at its base, two feet six inches, at Little Osage below the State line.

11. *Lower Coal Series*, 353 feet thick, in 24 layers, with five seams of coal: (1.) The upper and largest, five to seven feet thick, at Dorsey's coal-bank on Middle Fork, Cow Creek, in Cherokee County. Prof. Swallow saw but four feet of this coal, as the bank was caved in, but it was reported to be seven or eight feet thick in places. (2.) The next seam, 40 feet lower, is two to six inches of coal and smut. (3.) The next is also coal and smut, two to four inches, 69 feet lower. The fourth in descending order was but partially seen, and is probably the same as the three-feet bed on Cow Creek. The fifth is 120 feet lower, and is six to 10 inches of coal, on the Neosho, at the southern State line.

12. *The Lower Carboniferous Formation*, the lowest in the State, is found at Baxter's Springs, and measures 120 feet.

The total thickness of coal-measures in Southern Kansas is 2,000 feet, with 22 seams of coal, 10 of them over one foot in thickness.

The leading deposits now worked are those at Fort Scott, near the southeastern borders of the State, at Carbondale, Osage County, on the Atchison, Topeka & Santa Fé Railroad, and at

Leavenworth. The surface-veins at Fort Scott are about 20 inches thick, and covered with about three feet of what has been supposed to be slate, until recently a geologist has pronounced it cannel-coal of a good quality. It burns well, and has great heating properties. Throughout Kansas the Fort Scott soft coal has come into general use, and large quantities are consumed by railroads. The Kansas Pacific was, until lately, wholly supplied with fuel from this source. The Osage coal is now taking its place to some extent on the Kansas division, while the Boulder Valley Coal, to a great extent, meets the wants of the Colorado division. Several founderies at Kansas City, Leavenworth, and Lawrence, use the Fort Scott coal. The Osage coal-measures show the best results thus far. Some six or eight car-loads are delivered at Topeka daily for distribution to all points, while considerable quantities go down, *via* Emporia, to points on the Missouri, Kansas & Texas Railroad. The openings near Leavenworth are now supplying this and neighboring cities. On the Leavenworth, Lawrence & Galveston Railroad, near Ottawa, Franklin County, there are workable coal-beds, and that railroad is in a measure supplied from them. Openings have also been made at other points. Mining is of course in its infancy in Kansas. The whole attention of the past few years has been given to farming, and most of the large towns owe their growth to the fact that their position makes them supply centres and distributors or marts of commerce.

Twenty-two distinct and separate beds of coal have been traced out. Many of these are thin, and but of little practical value; but 10 of them range from one to seven feet in thickness of coal for domestic and manufacturing purposes. In this State, as well as in Missouri, the thickest beds are found near the base of the coal-measures. They crop out most plainly and abundantly in the southern portion of the State; while at Leavenworth, the coal-shaft was sunk 700 feet before they were reached. Some individual beds of coal are found which thin out toward the northwest, and others entirely disappear in that direction. Three of the beds that appear in Southern Kansas were entirely absent in the Leavenworth openings, and most of the others had thinned out to one-half or three-fourths their original thick-

ness. This increase of carbonaceous deposits toward the southern part of the State points in that direction for the fullest development of the Kansas coal-fields. The thick bed known in the Missouri Valley as the "Boonville bed" is traced as a continuation in Kansas. In the Leavenworth coal-mines, 700 feet below the surface, its greatest thickness is 28 inches, and thins out to 22 inches. At Fort Scott the surface was penetrated in two instances, by borings, to the depth of 300 feet and over, and each time passed through seven or eight feet of coal. A shaft was mined two miles from that town, and covering the distance of the borings, but no coal was found. South of Fort Scott, the "Boonville bed" is from five to seven feet thick. It is found that Eastern Kansas has an area of 17,000 square miles underlaid with coal; and probably a like area in Western Kansas, replete with lignite or brown coal.

C. C. Hutchinson, in his "Resources of Kansas," reports that in the shaft at Leavenworth, at the depth of 710 feet, an excellent quality of coal was found, the bed varying from 22 to 28 inches in thickness, averaging 25 inches. This mine has an excellent steam-engine, and good facilities for delivering coal. It is proposed to sink the shaft to a greater depth, as it is believed that a vein three feet in thickness can be reached at a depth of 1,000 feet from the surface. One of the upper coal-veins, much inferior in quality to the shaft-coal mentioned, was formerly worked a few miles distant from Leavenworth, and other veins have been worked in Northern Kansas.

The coals of the upper strata which are most worked are in Osage and Franklin Counties. The western portion of the latter county, and perhaps the entire surface of the former, with portions of the adjoining counties, are occupied by veins showing themselves in many places, and everywhere within a few feet of the surface. There is one company in Franklin County, and four or five in Osage County, that deliver coal on the railroads. The mines in these two counties show about 22 to 25 inches of solid coal. It is sold throughout the counties, at the the mines, for from 15 to 20 cents per bushel of 80 pounds.

Mining is prosecuted extensively by organized companies in Bourbon County, near Fort Scott, and in Crawford, Cherokee, Neosho, and Labette Counties. The veins that are worked in

this region range from two to four feet in thickness, and are but a few feet below the surface. Coal is found in workable veins in every county throughout the coal-formation, but approved methods of exploring and opening these veins have been employed in but few instances; very little, indeed, is known, as yet, of the resources of the State in this regard, and discoveries are constantly being made.

The Kansas coal, of which we have been speaking, is bituminous coal, and of a superior quality. There is considerable lustre to its broken edges, and it does not crumble to dust by handling and shipping, as does much of the coal in other Western States. It is used upon all the railroads, both for locomotive and machine shops. It is also extensively used for domestic purposes, and universally by blacksmiths. It is singularly free from sulphur, and burns with the clear, white flame of Pittsburg coal.

There is a species of coal in the western portion of Kansas classed as lignite. This is a distinction without an apparent difference to the ordinary observer, between the best specimens of it and the common bituminous varieties. It is a lighter coal, containing more gaseous matter and less carbon. Generally, the proportion of fixed carbon is so small that it is not suitable for smithing, but it answers well for heating purposes. From recent discoveries, it seems to have a wide distribution, and will play an important part in the settlement of that region. Little is really known about the mineral deposits of Western Kansas, as the State geological surveys have not extended so far, but there is evidence that among its abundant sources of wealth we must reckon the coal or lignite deposits as not the least valuable.

The following very valuable information in regard to the production of coal in Kansas in 1871, and as to the relative value of that produced in different localities, has been kindly furnished by A. B. Garwin, the General Fuel Agent of the Kansas Pacific Railroad, by permission of J. E. Bowen, Esq., the General Superintendent. The lignite mentioned as having been obtained from Carbon and Rock Springs mines, in Wyoming Territory, and the Golden City and Erie mines in Colorado, is here given to make the statement complete as to the Kansas Pacific Railroad:

STATEMENT OF COAL CONSUMED BY THE KANSAS PACIFIC RAILWAY DURING THE YEAR 1871.

WHERE RECEIVED.	From what Railroad.	Where Mined.	Quantity.	Total received at each point.
			Tons.	Tons.
State Line (opposite Kansas City)	M. R., Ft. St. & G.	Fort Scott, Kansas	8,598	
"	"	Coalfield, "	2,932	
"	North Missouri	Camden, Missouri	568	
"	"	Richmond, "	96	
"	"	Huntsville, "	44	
"	"	Renick, "	69	
"	Missouri Pacific	St. Louis, "	468	12,258
Wyandotte	"	Leavenworth, Kansas	1,218	1,218
Leavenworth	"	" "	5,228	5,228
Topeka	A. T. & Santa Fé	Carbondale, "	15,023	
"	"	Gables's Station, "	673	15,694
Junction City	M. K. & T.	Oswego, "	154	
"	"	Chetopa, "	929	
"	"	Fort Scott, "	75	1,158
Wilson's		Wilson's "	75	
Godfrey		Godfrey, Colorado	3,000	3,075
Denver Pacific Junction	U. P. & D. P.	Carbon & Rock Springs, Wyoming Territory	888	
"	Colorado Central	Golden City, Colorado	214	
"	D. P. & B. V.	Erie, "	20,698	21,800
			60,700	60,700

"In addition to the above, the Kansas Pacific Railroad transported for individuals 5,646 tons received at the following stations: State line, 1,844; Leavenworth, 1,076; Topeka, 2,162; Junction City, 143; Solomon, 33; Salina, 11; Wilson's, 13; Ellis, 7; and Denver, 357.

"Of the coal used by this railroad company, the 3,075 tons received at Wilson's (239 miles west from here[1]), South Godfrey, 566 miles distant, 73 miles east of Denver, are all that have been received from along the line of our road. This coal was obtained for the purpose of testing its value as a locomotive-fuel, and proved worthless. No serviceable coal has as yet been developed on this road. The coal from Fort Scott, 104 miles south of Kansas City, is what is familiarly known as the Fort Scott 'rusty,' or 'brown' coal, and is unquestionably the best for locomotives and smithing to which we have access. The Rock Spring Coal, from Wyoming Territory, is probably superior for locomotives. The Fort Scott coal occurs within a few feet of the surface of the ground, and is obtained by 'stripping.' It contains but little slate or sulphur.

"The Leavenworth coal, mined through a shaft 710 feet in depth, is the second in quality, in general use. Its only objectionable feature is the large proportion of sulphur, or iron pyrites, it contains.

[1] Kansas City.

"That from Coalfield, Cherokee County, 140 miles south of Kansas City, and Oswego and Chetopa, in Labette County, 175 miles southeast of Junction City, Kansas, seems to rank next in quality. It is strong in body, makes an intensely hot fire, and steams well. It 'clinkers' badly, and makes sad havoc with fire-boxes and grates. It is quite extensively used as a gas-coal, under the name of Cherokee. Next in rank we will place the Carbondale, more familiarly known as the Osage coal, occupying from 18 to 40 miles southwest of Topeka. It is not as strong as either of those previously mentioned, but has the advantage of being comparatively free from slate and sulphur.

"The coal from Golden City, and Erie, Colorado, comes from the bountiful deposits at the base of the Rocky Mountains. It is quite free from impurities, and burns freely and rapidly. It crumbles or slacks very quickly on exposure to the air and the sun, and for this reason it is placed last in the list of desirable coals. From Missouri we receive coal of considerable impurity and light in body. It crumbles rapidly, and is only used by this company in times of scarcity, when more desirable qualities are not to be had."

The United States census of 1870 reports 32,938 tons of coal as the production of Kansas for the previous year, of which 20,635 tons were from Osage County.

Lignite.—The existence of thick beds of good brown coal, over a large area in Western Kansas, has been ascertained. These beds crop out on the Smoky Hill from Cedar Bluffs, some 25 or 30 miles from Salina, in Saline County, westward. In thickness they range from three to seven feet, and they extend a long way up Smoky Hill, and probably beyond the western boundary of the State.

The importance of these vast beds of fuel along the valley of the Smoky Hill, in Central Western Kansas, can scarcely be estimated. Without them, this beautiful and fertile valley, destined to be the great line of travel to the Mountain States, would be but sparsely populated. But, with this abundant supply of fuel, towns and villages will spring up, surrounded by flourishing communities, whose surplus products will supply the mining population in the Mountain States.

XXV.

ARKANSAS.

The coal-measures of the United States appear to be divided into three members by two different and thick strata of sandstone, the Mahoning sandstone and the millstone grit. The upper member is underlaid by the Mahoning sandstone, which is sometimes conglomeritic in its upper part. This member, 400 to 500 feet in thickness, contains in Pennsylvania the great Pittsburg bed as its lowest coal-seam, with the Barren Measures below it. The second member in the descending order, of about the same thickness as the former, lies between the Mahoning sandstone and the millstone grit series, or conglomerate formation, and contains also from four to six workable strata of coal, two of which are generally from four to six feet thick.

The millstone grit, a variable formation, considering either the thickness or the nature of its strata, has been considered as the base of the true coal-measures; and the coal-bearing strata underlying it have been named by some geologists the False Coal-measures. But the fossil plants found in it prove that it is a true member of the coal-formations, and in some counties it contains two or three beds of coal which can be profitably worked.

All the coal-beds of Arkansas appear to belong to this lowest member of the coal-formations underlying the millstone grit. All the hills or mountains, at the base of which coal-strata have been found in Arkansas, are formed of shales, or various kinds of sandstones, all belonging to the conglomerate series, which reach here a great thickness. On the top of the highest mountains her geologists have failed to discover a trace of the coal, or

of the other measures which follow the millstone grit in the ascending order. The millstone grit, as well as the underlying strata near the western limit of the coal-basin, takes, apparently, a great development. Moreover, the extraordinary horizontality of the geological measures in Western Arkansas causes an extensive distribution of the strata containing the coal, either near the surface, or at a depth where the combustible material may be easily reached.

D. D. Owen, in his geological survey of Northern Arkansas, noticed with surprise the vast extent, both vertically and superficially, of the millstone grit and the associated shales. There were eight whole counties that were then known to be almost entirely occupied by this formation, besides a large portion of six other counties. Another fact with which he was strongly impressed was, the immense quantity of silex in the shape of chert, buhrstone, and chalcedonix flint, irregularly mixed and segregated among the other rocks, especially the limestones, or diffused as quartz, in veins among the sandstones. He reports that he had travelled for days and weeks upon these silicious formations, both among the rocks of sub-carboniferous and lower Silurian date.

Coal has been found and surveyed in 12 counties in Arkansas, and just in those that are farthest from the great coal-basins east of the Mississippi. The combustible mineral becomes still more valuable, from its situation along and on both sides of the Arkansas River. The counties of Washington, Crawford, Sebastian, Franklin, Scott, Johnson, Yell, Pope, Perry, Conway, White, and Pulaski, are all of them situated almost entirely in the coal-basin of Arkansas, and its productive strata may yet be extended into the adjoining counties. The field contains, in all, 9,043 square miles.

Two beds of coal have been found in Arkansas, but the lowest only as yet has been found of workable thickness. The sub-carboniferous measures generally underlie it at a short distance, and no coal can be expected to be found in them. The coal strata underlie, at a distance of 50 to 100 feet, a bed of red ferruginous clay, or red earth, which is easily distinguished wherever it appears, like the Umbral red shale of Pennsylvania.

The best and thickest coal as yet seen, in Arkansas, is the

32

Spadra coal, in Johnson County. It is a semi-anthracite, even richer in fixed carbon than the Zerbe's Run coal, of the Shamokin coal-field of Pennsylvania, and is pronounced by Dr. Owen superior, for manufacturing purposes, to any Western coal at present known, where durability, intense heat, and reduction, are required. It crops out close to the Arkansas River, above the mouth of Spadra Creek, and extends back into the interior of Johnson County. In some places, near the mouth of Spadra Creek, the coal is three and a half feet thick, including a clay parting of three inches, and about six inches of brashy coal. The same coal crops out above the town of Spadra, on the bank of the Arkansas River, where it is said to be four feet thick. It is thus probable that the same coal will be found all around the county.

The value of the coal-beds of a country is necessarily relative, and cannot be estimated by the price or the value of coal at another place. A coal-bed, like that at Spadra Creek, three and a half feet thick, producing about three feet of clean, semi-bituminous coal, will hereafter, when the demand increases, give to the owners profitable results. It is true that, in Arkansas, the working of coal will never excite such speculation and employ such a capital as in the great coal-producing regions, but, from what is known about the distribution of the sub-conglomerate coal in Arkansas, one has the right to assert that by-and-by coal will be found, if not in very thick strata, at least abundantly enough to supply the wants of the future manufacturing establishments of the country.

The fossil plants prove that the true coal-measures descend as low as the sub-carboniferous limestones, and even to the second bed of the Archimedes limestone. Not much coal is found there, it is true, but it is the beginning, the infancy of the epoch which, as at the time of its decrepitude, and near its end, has the strata of combustible matter scarcely formed, and thin.

The seams of coal found at various other places on both sides of the Arkansas River are reported at about 10 inches or a foot thick. But at the Jenny Lind prairie, in Sebastian County, the coal is four and a half feet thick, and has two clay partings of about one inch each. But the top coal, for about one foot of

its thickness, is a shaly or brashy coal of little value as a combustible. It looks like a brittle, black shale, intermixed with lamellæ of coal-matter, and full of broken remains of plants difficult to determine.

There is another locality where the coal-bed in Sebastian County, three and a half feet thick, is overlaid like the last by half a foot of brash coal. These two banks, compared with the thickness of the same strata in Crawford and Washington Counties, would, perhaps, indicate a progressive increase in the development of the sub-conglomerate coal toward the south.

The coal-seam in the southern part of Franklin and Johnson Counties does not appear to exceed two feet in thickness. Along nearly the whole course of Petit Jean Mountain, in Perry and Yell Counties, a seam of coal can be traced usually from one foot to 15 inches thick, occupying a position about 100 feet above the base of the mountain.

In the higher ranges, for instance, in the Magazine Mountain, coal of about the same thickness has been detected upward of 500 feet above the level of the farms in the plains below the mountain; whether this is the same, or a distinct bed of coal, has not been ascertained.

In Conway County the coal is from four to 20 inches thick. The following analyses are given of Arkansas coals:

	Jenny Lind.	Long's.	Yell Co.	Craven, Johnson Co. 11 inches.	Crawford Co. 1 foot.	Spadra Creek.
Water	1.40	3.80	3.00	2.00	1.00	0.5
Volatile Gas	12.35	10.70	11.40	7.75	15.20	7.9
Fixed Carbon	82.25	84.10	80.40	88.75	80.80	85.6
Ashes	4.00	1.40	5.20	1.50	3.00	6.0

These analyses, Dr. Owen says, prove the coal to be semi-bituminous, like some of the coal in George's Creek Valley, Maryland; but, in fact, these coals contain more carbon, and are anthracite or semi-anthracite. Being far richer in fixed carbon than most of the coals in the Western States, they are therefore almost twice as durable in the fire with proper access of air. The existence of a semi-anthracite or semi-bituminous coal in the West is the more surprising, as the formation is level and undisturbed, and bearing little evidence of metamorphism or

change by internal heat. There is, however, rock of undoubted igneous origin, 60 miles south of Johnson County, in Hot Springs County. The igneous rocks are no doubt near enough to the surface to have excited an igneous action, and to have expelled the greater portion of the gaseous matter. The peculiar fissured structure of the Spadra coal favors the idea that the volatile matter was expelled not only by prolonged chemical action, but by heat which causes an expansion of the particles, and that severing the coal gives it a friable tendency, and a peculiar subdivision into cuboidal lumps.

Indian Territory.—It will have been noticed that the coal-field of Kansas evidently extends over the north line, and that of Arkansas over the east line, of the territory occupied by the Indian tribes who were removed west of the Mississippi River. The coal-field of Texas also approaches the south line of that territory. All these facts indicate the existence of important fields of coal of which nothing is known in that beautiful country. The coal of Arkansas and Texas, too, although the beds are not large, is of unusually good quality for western coal.

XXVI.

TEXAS.

In the Reports of the United States Explorations for the Pacific Railroad, near the 32d parallel of latitude, Prof. William P. Blake reports that a number of seams of bituminous coal, varying in thickness from two to four feet, have been opened along the Brazos River, and the coal is made use of at Fort Belknap, in Young County, in the northwestern part of Texas. Dr. Shumard also states that the characteristic fossil forms of the Carboniferous era have been found with this coal, and considers the age of the formation established. Fossils obtained from the carboniferous limestone remove all doubt of the Carboniferous age of these deposits.

It is most probable that this coal-deposit is of great extent, underlying a broad area in Texas, and extending into New Mexico. The coal is said to be of a fair quality, and burns freely, leaving a white or gray ash, and does not cause any trouble in slagging. The coal-seam is four and a half feet thick, is horizontal, and divided in the middle by a thin layer of slate, from one to four inches thick. It has been in use at Fort Belknap for a long time, and extensive excavations were made into it in the bank. It is found at many places along the bluff banks of the river, where it has been opened into, and good coal taken out. The coal-seam was also found three-quarters of a mile from the fort, at a depth of 60 feet, in sinking a well. The coal at Fort Belknap can be taken out in large blocks and masses, but when exposed to the air they fall to pieces.

B. F. Shumard, in his first geological report of Texas, published in 1859, says the area of this coal-field may be reasonably estimated at from 4,000 to 5,000 square miles. From Fort

Belknap it extends uninterruptedly southeastwardly to Patrick Creek, in the southwest part of Parker County, more than 160 miles, westwardly about 40 miles, and southwestwardly beyond Camp Colorado, in Callahan County, 100 miles. No trace of it can be seen in a northern direction more than six or eight miles from Fort Belknap, but it is highly probable that it reaches in that direction into Archer, Baylor, and Clay Counties. It is probably the same formation that is developed in San Saba and some of the counties adjacent on the Colorado River nearly south of Fort Belknap.

The strata composing the coal-measures of Texas have a thickness estimated at not less than 300 feet, containing fossils characteristic of the coal-measures of Missouri, Iowa, Illinois, and Kentucky, and the coal produced is of the same general character. In Young County, in which Fort Belknap is situated, and Buchanan County, south of it, and in Palo Pinto, adjoining it on the east, outcrops of coal appear at a number of points. Mr. Shumard gives an analysis by Dr. Kiddell of coal from a three-and-a-half-feet seam on Whiskey Creek, two miles north of Fort Belknap, showing moisture, at 212°, 7.9, other volatile matter 36.3, fixed carbon 52.8, and ashes 3.0. Other samples of coal from Denton County, directly east of Fort Belknap, are elsewhere reported as yielding 36. of volatile matter, 61. of carbon, and 3. of ashes, and other samples from Burleson County, near Washington, Texas, are reported as yielding 22. of volatile matter, 75. of carbon, and 3. of ashes.

S. B. Buckley, in his report in 1866, says there are from two to four seams of coal at Fort Belknap, and about six miles north of that place is a bed of coal five feet thick. He describes the country as undulating, with hills from 100 to 200 feet high, with gentle slopes. The blacksmiths of the country say it is a good quality of bituminous coal, and little if any different from the coal of the Western coal-fields in Ohio, Illinois, and Kentucky. Besides the coal-area just described, it is highly probable that productive coal-beds will be discovered in the extreme western portion of Texas. Fossils of the coal-measures have been found in the Hueco Mountains, and coal is reported to have been found in El Paso County.

Connected with the tertiary formation, which occupies a vast

area in the eastern and middle portions of Texas, are extensive beds of brown coal or lignite, which may become of great service to the public. Prof. Shumard's detailed examinations in Rush County show that a large portion of this county is underlaid by deposits of this material, exposures of which occur at a great many localities, the beds varying from six inches to eight feet in thickness. At a number of localities the lignite appears to be of good quality, and adapted to the ordinary purposes of fuel. It varies greatly in character in different sections of the county, some specimens exhibiting the woody fibre with tolerable distinctness, while others show no traces of organic structure, being dull, shining-black, and very compact in structure.

Rush County is in the northeastern part of the State. Regular seams of lignite, of more or less value, have also been discovered by the geological corps in the neighboring counties of Harrison and Cass. In the northeast corner of the latter, near the corner of the States of Arkansas and Louisiana, at Stone-Coal Bluff, there is a bed of lignite ten feet thick, which resembles the bituminous coal of Fort Belknap both in chemical composition and external character. Grayson County, on the Red River, the north line of the State, is also mentioned as containing lignite. Another region of the State on the Colorado River, south and southeast of Austin, produces lignite, being the counties of Bastrop, Fayette, Caldwell, and Guadalupe.

S. B. Buckley, in the report before referred to, mentions beds of lignite which he measured near Bastrop, which were five feet thick. They are also quite common in Fayette County and Brazos, Burleson, and Milan, on the Brazos River, and in some of the counties on the Trinity River and on the Red River, in the northern part of the State. Some of the beds are so thick and of so good a quality as to be valuable for fuel.

Beds of lignite or Tertiary coal are found at many other places in Texas. A bed four feet thick is found on the Colorado River, near Bastrop, beneath a layer of Eocene fossils. It also occurs on the Brazos, at the mouth of the Little Brazos. These localities are, however, nearly 200 miles distant from Fort Belknap, and, being of a different age, have no connection with

the deposits at that place. It adds to the importance of the Fort Belknap coal that none has been found west of it.

Prof. Jules Marcou, geologist of the United States survey, from the mouth of the Arkansas River to Pueblo de Los Angeles, says: "We have not met upon our route with beds of coal, but the presence of the black slate between the mountain limestone and the red clay of the Trias indicates the existence of beds of coal on several points of the Rocky Mountains, and, indeed, the inhabitants of New Mexico pointed out to me in several places beds of bituminous coal, belonging, without any doubt, to the rocks of the coal-measures." Later researches, however, indicate that they are cretaceous. Also Prof. William P. Blake, in his report of the geology of the routes in California to connect with the routes surveyed near the thirty-second and thirty-fifth parallels, says the geological formation examined by the survey is not such as to indicate the existence of mineral coal of the age of the Carboniferous.

But it is unnecessary to enumerate localities where coal has not been found, especially in such vast wilderness regions, where coal and other valuable minerals, if they exist, can only be discovered after the country becomes inhabited.

Here closes the history of the Carboniferous coal-fields of America, except that of Nova Scotia, which will be found in Chapter XXXII. The remaining two eastern coal-regions to be described, namely, those of Virginia and North Carolina, are of the Triassic age; while those in the western part of the continent are Cretaceous or Tertiary. A look backward, over the vast fields of buried fuel through which we have so hastily travelled, will satisfy the reader of the greatness of our subject, and that this is but a hurried sketch of a picture, all the details of which would require many volumes.

TRIASSIC COAL.

XXVII.

VIRGINIA.[1]

The coal-field near Richmond, in Virginia, is situated in the counties of Chesterfield, Powhatan, Henrico, and Goochland, about thirteen miles west of the city of Richmond. Its boundaries are given in detail in W. B. Rogers's State Geological Report for 1840. The length of its area, from its most northern to its most southern termination, is about 30 miles, and its greatest breadth about eight miles. There are several small outlying basins on the eastern margin of the field in Chesterfield County, and also several small diverging branches near its northern margin. R. C. Taylor, in 1848, estimates the whole area at 185 square miles. Nearly opposite to the extreme northern part of this coal-field, and separated by about three miles of primary rocks, lies the small coal-tract known as the Springfield and Deep Run basin. It is about two miles in length and a quarter of a mile in width, its most northern termination being a short distance south of Chickahominy River.

It is important to remark that, after much investigation as regards the true geological character of these coal-basins, Prof. Rogers became satisfied that they are of more recent production than the Carboniferous strata of Western Virginia, and most of the European coal-measures. Well-preserved fossils are rare in these coal-fields, and it was originally a very perplexing inquiry, but some have been procured, and various other data have served to illustrate this interesting question. The

[1] From reports of W. B. Rogers, R. C. Taylor, and J. P. Lesley.

coal-field of Richmond, Virginia, is not at present as important as it once was as a great coal-producing region, but it presents many curious features, and in a work of this kind it is necessary that correct information in regard to it be given. Its geological position is truly remarkable, as it reposes within an extensive depression or trough of granite, with large feldspar crystals. Outside of the granite next occur sienitic rocks and quartzose schist, gneiss, hornblende, slate, and other primary rocks. The granite declines at a great angle toward the west on the eastern margin of the coal-region, sinking to an unknown depth below it, and rising again at a gradually-increasing angle in an opposite direction toward the western margin. The coal-beds crop out immediately over this granite on both sides, evidently conforming to the configuration of that rock. It is an interesting occurrence that this coal-deposit rests upon granite without any interposing rocks, except occasionally a few inches of coal-shale.

The western outcrop is commonly termed the upper seam, and the eastern the lower seam, but on careful examination the geological continuity or conformity of the whole becomes too apparent to leave room to doubt that it is one coextensive deposit filling up a trough of uncertain depth in the primitive rock.

So rapid is the descent of this rock and consequently of the superincumbent coal-beds, that the numerous collieries within its limits in 1835, instead of being distributed, form a chain of works ranging in a line along the margin both at the eastern and western outcrops, seldom extending farther into the basin than from a fourth to a third of a mile. The extreme points in a north-northeast direction, where coal-traces exist, are about 35 miles apart, that is to say, from the Appomattox River to the forks of the Pamunkey.

The upper seam, which is also the thickest, consists of the best quality of coal, while the lower seam is comparatively inferior and depreciated by sulphuret of iron. Two or three coal beds or seams of variable thickness comprise from 11 to 40 feet. Commencing on the northeast part of the coal-field we find the coal in two seams, amounting together to from 10 to 17 feet. On the northwest side are two seams, in Anderson's or Graham's pits, 30 feet asunder, the highest

being from six to 16 feet, the lower from four to eight feet thick. These seams are said to come together farther north. At the River pits, on the south side of James River, in some old workings at the depth of 130 feet, was a 20-foot seam of a quality equal to any in Virginia. This work was suspended on account of the seam being "nipped out" by the granite. Crossing to the east side of the coal-field, we find some extraordinary sections of this mineral. Hill's pit contains three seams, of five, six, and 25 feet. In Mid-Lothian, or Wooldridge's pit, the coal in one seam is worked above 30 feet, and in parts of the same mine is occasionally much thicker. In the Maidenhead, or Heath's mine, Prof. Taylor examined a gallery cut in a solid seam of splendid coal not less than 25 feet thick. The Black Heath coal, which is reported the finest quality in the district, is 40 feet thick. In Hill's three pits the coal varies from almost nothing up to 40 feet, and the whole seam amounts to 60 feet, including some courses of shale. The Creek pit has one bed of six feet, separated only by a six-foot bed of shale and rock from the main bed of coal, which is here 48 feet, including two feet of shale; we have here, therefore, an aggregate of no less than 52 feet of clear coal. So great an accumulation of bituminous coal in large solid seams as is presented in these Richmond or Chesterfield pits is a highly-interesting geological fact, without a parallel on this continent. As may be inferred from the configuration of this coal-field, the shafts are sunk to depths which are regulated by the distance from the outcrop. North of James River, Willis's shaft was about 130 feet deep; many others were over 300 feet. There were then twelve old shafts, ranging parallel with the crop on the north side of the river, and within a mile. Graham's or Anderson's deep shaft was 450 feet. On the south of James River all the shafts were from 400 to 500 feet deep, and the Mid-Lothian 500 feet, and the workings carried to a depth of 700 feet. Some of the mines had been on fire for some time; Hill's Bell shaft had been burning for twenty-five years. The coal is of the white-ash kind, of a crystalline structure, highly bituminous, burns to a coke, and forms a hollow fire. The quality of coal varies in most of the mines; that of Black Heath had long commanded the highest price in the

market. But in all of the mines there are portions of the beds, particularly toward the bottom, where the quality is inferior and sulphury, the introduction of which has injured the general estimation of the Richmond coal. One of the curiosities of the region is the natural coke of Chesterfield County. This curious material occurs in a heavy bed at the eastern margin of the basin toward the James River. It has the aspect and composition of a coal which has been in great part deprived of its volatile ingredients by heat, accompanied by such a pressure of the overlying strata as would prevent the puffy cellular texture usually assumed by coke. Retaining all the carbon of the original coal, this material has great value as a combustible, yielding the intense and steady heat of anthracite, at the same time that, from its less compact texture, it is more readily ignited than coal of that description. By Prof. Rogers's analysis the more compact variety yields 80.30 per cent. of carbon, 9.98 of volatile matter, and 9.72 of ash.

These coal-measures, or the rocks in which the coal is found, come under the head of carbonifcrous, gritty, micaceous, or argillaceous shales. Portions of them consist of white and gray micaceous grits, some of them fine, others approaching to the character of conglomerates, yet containing feldspar-crystals like porphyry. These grits and some of the shales appear to have originated solely in the destruction of primitive rocks, and the whole series of these mechanically-formed strata is especially remarkable for the abundant prevalence of mica, and, at intervals, of carbonaceous particles. The quality and thickness of these beds of rocks are subject to important variations, but the prevailing character of the whole group remains unchanged.

The general range or longitudinal direction of this Richmond coal-field is nearly north-northeast and south-southwest, and its structure is that of a true but very oblong basin, composed of a thick series of variously-constituted sandstones, superimposed upon two or three seams of bituminous coal, themselves resting almost immediately in contact with the surface of the primary rocks of the surrounding region. Every thing lends countenance to the opinion that the surface of the primary rock, previous to the deposition of the carboniferous matter, was a valley

of rolling outlines, occupied by hollows and elevations, causing the first layers of matter which were thrown down to be deposited in greater thickness in some places than others. As the lowest coal-seam is separated from the crystalline rock beneath by only a few feet of shale, and in some cases by none at all, it appears likely that the distribution of the coal was made unequally in thickness from the very commencement. There are numerous instances of the coal filling up hollows as it were in the floor, being accumulated in saucer-shaped basins to the thickness of 40 or 50 feet, and resting in comparatively thin masses upon the eminences in the same floor. In some instances these subordinate basins are almost entirely insulated from the rest of the coal-field. The upper surface of the coal is also affected by similar undulations, which only goes to show that the deposition of the coal did not sufficiently fill up the original inequalities upon the floor to make a perfectly level surface for the reception of the deposits which succeeded.—(W. B. Rogers's Report of 1836.)

After this coal has been excavated and its base is laid bare, the floor of the mine exhibits the original undulating surface of the granite, and in some few instances the eminences which protrude from this ancient surface rise entirely through the lower carboniferous beds, as, on a larger scale, an island rises above the waters of the ocean. Thus the floors of the deep galleries present an irregularly undulating surface, to the inconvenience of the miners, and occasioning obstacles to the formation of subterraneous railroads. It is not always that the coal rests immediately on the granite. Occasionally there is a foot or two of black carboniferous shale, or a seam of from one to six inches of dark porphyritic rock. Often many square yards of the granite are laid bare, when its surface appears smooth, as if worn by previous attrition before the deposition of the vegetable matter had commenced. There exists no parallelism between the upper and lower surfaces of the main coal-seam, neither does the roof present the usual continuity of planes as is seen in ordinary stratified deposits. In these lower thick seams the roof is irregular, rising and falling, swelling and expanding, without, at the same time, conforming to the undulations of the granite base.

The parallelism of the laminæ or planes of stratification within the body of the coal itself, however, is not interrupted, but they continue of uniform thickness parallel to each other, and with the prevailing dip of the coal. The prevailing circumstances which are developed in this remarkable mass of coal are such as would be expected to attend the deposition of vegetable matter, or of any substance in fact not altogether in a state of fluidity, yet capable of entering into and filling up the innumerable inequalities and minor cavities in the original granite bed, and of at the same time maintaining in the plane of its own superior surface a certain general parallelism or level. They thus furnish a ready explanation as to the otherwise singular irregularities in the thickness of the great lower coal-seam, so different from the usual characteristics.—(Taylor.)

"Granite, gneiss, and mica slate, surround the Richmond coal-field and form its bed. Upon this face of granite was deposited a coal-bed varying from 10 to 60 feet in thickness, dipping east from 25° to 80° on the west side of the basin, and dipping west from 20° to 40° on the east side of the basin.

"The geological history of the Richmond coal-field is easily understood. There was once a time when a mountain-range of granitoid rocks rose high above sea-level, where Richmond and Petersburg now stand; and stretched away northward through Virginia, Maryland, and Southeastern Pennsylvania, as far as Trenton, on the Delaware River. Toward the south it ranged past Raleigh and Fayetteville to the Dahlonega country of Georgia. A few miles farther west, another and lower mountain range ran parallel to the first, but united with it before reaching the Potomac River. The valley between these two ranges of mountains was everywhere at least 1,000 feet deep, and may have been of twice that depth. Its length was at least 300 miles, and may have been 400.

"We know nothing about the condition of the Atlantic Ocean coast at that time; but we know that the coal-measures of Pennsylvania, West Virginia, East Tennessee, Ohio, East and West Kentucky, Illinois, Missouri, Iowa, and Kansas, had all been deposited to the last and topmost layer. The carboniferous sea had been drained, and its bed lifted many hundred feet above tide-level. The Eastern coal-measures, with all the

formations under them, in all more than 35,000 feet thick, had been bent by lateral pressure (from the shrinkage of the planet, or some other cause) into folds, or waves, the crests of which must have been, in some cases, five miles above the level of the sea. There is nothing surprising in this, seeing that all Central Asia stands at the present day at about this height, while its southern border for 1,000 miles in length has even a higher elevation. The uplift of the still longer belt of the Andes is another living example of the same kind.

"From the Hudson to the James, the newly-formed, enormous barrow-shaped mountains stretched along the country, and in the front of them were the (by that time) very ancient mountain-ranges of granite and schist rocks, worn down already to half or two-thirds of their original height.

"Erosion goes on in all ages. From the moment the coal-measures were lifted into the sky, ice and water began the long task of their destruction which has continued ever since; until, now, in this year of our Lord 1871, no point of all that vast Himalaya coal-country can be found which measures even 4,000 feet above the sea. Thousands of square miles of country, once covered with 4,000 feet of coal-measures, possess no longer a single ton of coal, and have even lost all the formations underneath the coal, down to the limestones of the Silurian system. The coal-field once spread eastward as far as Newburg, Easton, Reading, Harper's Ferry, Lynchburg, and Atlanta. Now, nothing has been left of it between this line and the crest of the Alleghany or Cumberland Mountain, but a few small patches, preserved in a few extra-deep folds, such as the anthracite basins and Broad Top in Pennsylvania, and Lookout Mountain in Georgia, or along cracks in the crust, as at Augusta Springs and Blacksburg, in Virginia.

"But geologists no longer give sudden deluges the credit of all this destruction. The Alps are wearing away with great rapidity, before the eyes of the people of Switzerland, without the agency of any deluge. The glacier and the torrent are quite competent, alone. So they must have been in the times succeeding the uplift of the coal-measures. But even glaciers and torrents require time for the performance of their immense task—immense time.

"During the post-carboniferous ages, the Permian, Triassic, and Liassic formations were deposited in a hundred seas and lakes, and along the shores of all oceans around the world.

"It was at this time that the Connecticut River Valley was filled with its brown building-stone, on which are multitudes of reptile-tracks; and some of the reptiles of that day were winged, like bats—*pterodactyls*. At the same period the estuary which ran up through Southeastern Pennsylvania, between the South Mountain or Blue Ridge on the one hand, and the Philadelphia-Baltimore Mountains on the other, was filled with the Newark and Norristown brown building-stone.

"At the same time that Middle New Jersey, Eastern Pennsylvania, and the Piedmont country of Virginia, and North Carolina, were receiving these New Red deposits in a long, wide estuary or arm of the sea, having its capes at Trenton and Manhattan Island, the valley, described at the beginning of this sketch as lying between two ranges of mountains which stood where Richmond and Raleigh are now, got also filled up with over a thousand, and perhaps with several thousand feet of sand and mud. These are the Richmond coal-measures.

"The valley had, of course, irregular, bossy sides, like all valleys between granite mountains. On its two slopes, and in its bed, grew one of the rankest vegetations ever seen; a vegetation chiefly of moss, on and through which grew many species of ferns and shrubs long since extinct, and also an irregular forest of trees of species also extinct.

"So deep was this growth of moss all over the valley, that, when subsequently covered up, and pressed down by a thousand or more feet of rock, and crystallized, it made a bed of bituminous coal varying in thickness from seven or eight to even 60 feet.

"This is the bed which the shafts of the Midlothian and Clover Hill collieries reach at various depths of from 400 to 800 feet. The coal having grown on the sides of a valley, shafts sunk near the edge of the field are shallow, while those toward the centre of the field are deep. The greatest depth of the ancient valley beneath the present surface has never been made known. But all the shafts as yet sunk descend through sloping strata of *psammites*—or granite-like sandstone, the washings of

surrounding granite mountains into the valley, when, after the growth of the coal-bed, the continent was again sufficiently depressed below the ocean-level to turn the valley into a lake, or into an arm of the sea—to the same thick coal-bed close over the granite floor.

"Had the valley been previously half filled with water, and this lake been filled up with washings from the sides, there would have been made in time broad level meadows, and the coal-bed would have been both regular in thickness, and horizontal in position; or, if the movements of the earth disturbed its horizontality, the dip and strike of the bed would have obeyed some regular law, which geologists might discover, and miners conform to. But the fact seems to be that the coal-bed was formed almost immediately after the valley itself was excavated, and therefore upon a very irregular surface, and in very unequal thicknesses, filling as it were ravines and basins, in the sides and bottom of the ancient valley, which has made mining an embarrassing business.

"This geological difficulty, however, will not stand in the way of the proper development of the Richmond coal-basin, when those, into whose hands its property tracts fall, learn that before a shaft is sunk *the whole ground of any proposed colliery must be carefully studied with the diamond drill.*

"We have often turned with a sort of wonder to regard the Richmond coal-basin. Its history is very strange. It was one of the earliest opened by the miner. It is the solitary one at tide-water and near a State capital; for the Rhode Island coal-basin does not deserve the name. It contains several beds of coal, and one of these is sometimes of great thickness, even 60 feet. It is mined by shafts on the English plan, and affords a variety of fuels, ranging from gas-coal to native coke. One would have expected its complete development long ere this.

"A little reflection, however, will serve to explain the phenomenon. The Richmond coal-basin is in Virginia; and Virginia has been in a profound sleep for a hundred years, a sleep undisturbed by dreams of any other than a political complexion. Industry was always ignoble in Virginia. Speculation in money-making was always under a sort of ban. Investment in unwieldy breadths of soil was the only vogue. The manufac-

turing element of society was carefully excluded from the Commonwealth. Wood was always plenty for the hearth and the forge; why raise stone-coal, where there were neither steam-mills, cotton-mills, nor woollen-mills, coke-stacks, nor puddling-furnaces in the region? The Tredegar Iron-Works could supply itself from Baltimore, or raise enough from a single shaft, with 50 black miners, to supply all its own needs. From the Blue Ridge to the sea-shore, and from the Potomac to the Savannah, no one thought of using stone-coal for any purpose whatsoever. If they had, the capacity of the Richmond field would have been well developed; for it stands, or stood, alone, the solitary source of mineral fuel for a region 500 miles long, and 250 miles wide. The Deep River basin was almost, and the Dan River basin was wholly, unknown. Even now, the latter remains practically untouched, and the former is not to be compared with the Richmond field for situation and size of beds."—*Lesley's United States Railroad and Mining Register*, Philadelphia.

The Richmond coal-region has been longer known and worked than any other in the United States. Long before the discovery of the anthracite deposits of Pennsylvania, or the introduction into use of that species of fuel, Richmond supplied the country with coal on the seaboard. But its interest now is historical and geological. Its trade has been taken, and now belongs, in vastly-augmented amount, to Schuylkill and Lehigh, Wyoming and Lackawanna, but more especially Cumberland and Broad Top. The following are R. C. Taylor's statistics of the annual shipments of Richmond coal for 20 years:

1822......	48,214	tons.	1829......	83,357	tons.	1836......	110,714	tons.
1823......	39,255	"	1830......	91,786	"	1837......	100,000	"
1824......	59,857	"	1831......	93,143	"	1838......	96,428	"
1825......	59,571	"	1832......	117,878	"	1839......	85,714	"
1826......	79,143	"	1833......	142,587	"	1840......	78,571	"
1827......	75,643	"	1834......	110,714	"	1841......	71,071	"
1828......	89,357	"	1835......	96,438	"	1842......	68,750	"

The Baltimore & Ohio Railroad commenced carrying coal to market from the Cumberland basin in 1842, but eight years were required before a market was obtained for 100,000 tons, the Richmond coal, meantime, going out of use. Since the close of the war, the Midlothian, Clover Hill, and others of the Richmond mines have been reopened, and the census of 1870

reports 61,803 tons of coal as mined in Virginia in that year. This oldest of our coal-fields is yet to see its best days.

W. B. ROGERS'S ANALYSES OF THE COALS OF THE RICHMOND COAL-BASIN IN VIRGINIA.

	Carbon.	Volatile Matter.	Ash.
SOUTH SIDE OF JAMES RIVER.			
Stonehenge	58.70	36.50	4.80
Engine Shaft—Maidenhead.	63.97	32.83	3.20
" —Heth, Potts & Co	62.35	37.65	2.80
Creek Pit—Mills & Reed	57.80	38.60	3.60
Nolt's Pit	62.90	32.50	4.60
Green-hole Shaft	67.83	31.17	2.00
Colonel Heth's—Deep-shaft coal, 30 to 40 feet	53.86	35.32	10.82
" —Middle of Seam	66.50	28.40	5.10
" —Top of Seam	61.68	28.80	9.52
Powhatan Pit—Colonel Finney	59.87	32.33	7.80
SOUTH END OF BASIN, NEAR APPOMATTOX RIVER.			
Cox's Mine—Winterpock Creek	65.52	29.12	5.36
NORTH SIDE OF THE JAMES RIVER.			
T. M. Randolph	66.15	30.50	3.35
Coalbrookdale	66.48	29.00	4.52
Anderson's	66.78	28.30	4.92
Barr's Pit—First Seam	70.80	24.00	5.20
" —Second Seam	54.97	22.83	22.20
" —Third Seam	65.50	24.70	9.80
" —Fourth Seam	56.07	24.33	22.60
Crouch's—Upper Seam	64.60	30.00	5.40
Scott's Pit	60.86	33.70	5.66
Waterloo	55.20	26.80	18.00
Deep Run	69.86	25.16	5.00

XXVIII.

NORTH CAROLINA.

The following account of the Deep River and Dan River coal-fields of North Carolina is chiefly taken from Prof. Ebenezer Emmons's reports as State geologist:

Various opinions have been expressed concerning the value of the coal-fields of this State, not without facts favoring these discordant opinions respectively. The first point, therefore, for the State geologist was, by examining in detail the deposits in immediate proximity to the coal, to establish whether the series of rocks in which coal was here known to exist actually form of themselves such a succession of rocks as to entitle them to the rank of the regular coal-bearing deposits, analogous, at least, to what has been determined in other fields where coal constitutes a part of the series. It is, however, never expected that every member of a group will be present in all localities, or that they will present or possess the same characters as to color, thickness, and mineral composition, etc.; still, certain characteristics will be found in common.

The position of the carboniferous or coal-bearing rocks in the general geological series is not far from the middle of the water-formed rocks, when there seems to have been a period fitted to the production of those plants which formed the coal itself. This middle period furnishes the best workable beds, and neither above nor below, though the sediments are very thick, do they bear coal. This conclusion is the result of observation extended over all the accessible history of the earth's crust. We do not assign a cause, for it is the fact that is important. Still the fact implies that the condition of the atmosphere, its

temperature and humidity, favored the production of vegetation of that kind, and in sufficient abundance to give origin to the coal. The position which the coal-rocks occupy is not theoretical, but has been determined by observations extended over a large portion of the earth's crust. Where the thickness of the coal-bearing rocks is great, room and space are thereby given for containing coal.

It is conceded that the geological position of the coal-bearing rocks of North Carolina is not the same, and that they are not of the same age as the Pennsylvania coal-rocks. We have, therefore, to look about for those which we may satisfy ourselves are of the same age as those in this State, and which have been proved to contain a large supply of coal. We are not left without examples in point, for the rocks of the Richmond coal-field establish the important fact that rocks newer than those referred to are coal-bearing, and they are shown by Prof. William B. Rogers to be of an age newer than the rocks of Pennsylvania.

Prior to the Carboniferous age we find no coal, but as we approach it we see the signs of preparation: plants appear and increase in numbers, until finally they reach their maximum in this particular period, where we find all the necessary materials and circumstances for the formation of coal, and it is not until we reach the rocks called carboniferous that it is found.

The members composing the series of rocks in North Carolina, in which coal exists, we find, on comparison, show an agreement with other coal-fields in the conglomerate, the sandstones, shales, fire-clay, and nodules of argillaceous oxide of iron. All the fields furnish one or two fossils in common; all of which, when put together, render it probable that the series actually form a coal-field, or a series, which are truly coal-bearing rocks. The members, then, which may be regarded as common, and, indeed, essential to a coal-bearing series, are present in the North Carolina formation. The conglomerate, the slates, the fire-clay, iron, and fossils, all point to the existence of a distinct coal-series, though not of the age of the Pennsylvania coal.

The only rocks in North Carolina in which coal will ever be found are the sandstones and slates herein described. The primary slates, though they may be dark colored, or even black,

do not derive their color from vegetable matter, but from fine sulphur diffused through the rock, and which has been derived from the sulphuret of iron, and hence may even exhibit a feeble combustion upon the fire.

Probably more money has been wasted in searching for coal than any other mineral. Wherever black slates appear, they are perforated somewhere with a shaft in search of coal. One of the great benefits of the New York survey was the determination that there was no coal there, and it has put a stop to the useless expenditure of money in this way. All these mistakes and errors were committed from inattention to the special and general characteristics of a coal-field.

The Deep River Coal-Field.

The Deep River coal-field is in the form of a trough, the inferior rocks extending farther than the superior. They may be regarded as beginning in Granville County, in a wedge-form or pointed mass. The northwest and west outcrop runs at first west of south, and passes through a part of Wake County, and sends up a short arm to within three miles of Chapel Hill. The direction of the outcrop has now changed to south 50° west, which course is preserved to the South Carolina line, the outcrop running about six miles west of Carthage. The uplift of this coal-field has been made upon the northwest side, where its line of demarkation is distinct, while upon the southeast side there is no outcrop. All that is there in view is the superior rocks still dipping southwest, their lower edge being concealed beneath a thick mass of soil. The dip is variable, being, on the south side of Deep River, south 60° east, north of the river, south 50° east, at the eastern end, at Farmville, south 10° west, and at Hornesville, south 45° west.

The lithological character of the whole system may be classed as conglomerates, sandstones, soft and hard, gray, red, and variegated, or mottled and green and black slates, with certain subordinate beds. The coal-series of Deep River from the bottom are: 1. Conglomerates and sandstones, 1,500 feet thick; 2. Black slates, with their subordinate beds and seams of coal, 500 to 600 feet thick; 3. Sandstones soft and hard, with the freestones, grindstone grits, and superior conglomerates, 3,000

feet thick—in all, 5,000 feet. 1. The conglomerate is formed of quartz-pebbles rounded by attrition, and occurs in oval masses, rarely spherical, standing out of the rock in strong relief. These pebbles have, in process of time, become consolidated without the aid of any cementing substance, and they are so strongly held together that in fracturing the rock they are broken through without being thrown out or loosened from their beds. The beds are two and sometimes three feet thick, separated by thinner and less perfect masses, composed of fine materials. The superior are less consolidated than the lower, or those below the coal. The colors are gray, brown, and red; generally the conglomerates are gray, and furnish no fossils except lignites in the softer portions. The whole thickness of the inferior conglomerates does not probably exceed 60 feet.

This inferior conglomerate rests immediately on the stratified pyrocrystalline rocks, the talcose slates, hornblende, gneiss, with thin subordinate beds and veins of quartz, and upon the edges of those inferior and older rocks, which proves that the inferior had been elevated more or less prior to the deposition of this system, and sufficiently to raise up their edges upon which the conglomerates rest. The sandstones succeed the conglomerates in the ascending order, and are variously-colored strata of red, gray, and olive; the predominant color is red, passing into brown.

2. The slates rest upon the conglomerates. They are thin-bedded, tender, and easily broken. They are green and black —rarely red. The coal, fire-clay, and argillaceous iron-ore, belong to this division. The fire-clay is quite fine, of a greenish color, and becomes soft when exposed to the weather. It is often traversed by roots of ancient vegetables, which gave origin to the coal.

Coal-Seams.

There are five coal-seams which have as yet been brought to light, and it seems to be established by observation that they are quite constant, and their thickness is given at three feet, one foot, three feet, two feet and four feet. This is at Farmville and Hornesville mines.

At Taylor's mines the seams are 18 to 30 inches, 2½ to 3 feet

and 4 feet respectively. At Wilcox's, still farther to the southwest, the coal is non-bituminous. The Murchison seam at the outcrop contains more slate, but the seam is said to be eight or nine feet thick.

There are indications that there are other coal-seams. Slates overlie all the coal-seams, their thickness being about 350 feet, and they are of a greenish color, with hard layers alternating with them. There is a great sameness in their appearance and composition, and uniformity in their thickness, showing that they are constituent parts of a great formation, which required an extended period for their deposition. They are here called slates, but should be called marls, or marly slates; having lime as a constituent part of their composition, they are liable to decomposition, and contain no sand except in combination with alumina. It is an important fact to remember that the coal is associated with these slates. Although the sandstones above and below are much thicker, still they contain no coal. The coal-strata lie below the middle of the slate-beds. The shaly sandstones, which are mostly red, sometimes green, but never black, show very conclusively that vegetable matter is very sparingly disseminated through the beds, and that the conditions required for the growth of coal-plants were not repeated during the era of these sandstones. Lignite is found in the sandstones, just above the conglomerates. It consists mainly of trees converted into coal, flattened by pressure, and made to assume the form of a thin coal-seam. They are instructive as geological facts, but they are not beds of the least economical importance.

3. The upper division of this system of rocks, resting on those in which occur the coal-seams, is made up of a series of hard, red, brown, and mottled sandstones, a repetition of the lower series or No. 1, so far as their composition and origin are concerned, destitute of fossils, except a few indeterminable vegetable casts.

Quality of the Deep River Coal.

Several varieties of coal, the bituminous and semi-bituminous, passing into the anthracite, are known in this coal-field. The bituminous is scarcely equalled for fineness and excellence

in this country. It is quite free from smut, and does not soil the fingers. It burns freely, and forms a cake, or it undergoes a semi-fusion, and agglutinates, forming a partially-impervious hollow cake, within which combustion goes on for a long time. It is easily kindled, and may be ignited in the blaze of a candle; is highly combustible, and burns with a bright blaze. It may be burnt in a common fireplace, and has been used for many years in blacksmiths' forges. It makes an excellent coke, which may be used for manufacturing purposes; it is free from sulphur, and valuable for the manufacture of carburetted-hydrogen gas for illuminating purposes. For the forge and steam purposes it is not surpassed.

The localities which have been best explored are Hornesville and Farmville, both in the same neighborhood. The Taylor mine, the Gulf, or Horton, and the Murchison mines, all furnish a bituminous coal. The Horton mine has been used the longest. It was known in the Revolution, and a report made to Congress respecting it still exists.

Extent of the Field.

This formation is known to form a belt of rocks from 12 to 14 miles wide; the line of outcrops of the slates upon which coal has been raised is about 20 miles. But the line of outcrop of the unexplored slate which embraces the coal is at least 60 miles within the State, on a line running south of west. We may safely assume that the coal-beds extend from the northern outcrop three miles beneath the sandstone, which is about one-third their natural extent, and that the line of outcrop upon which coal is, and will be found, is 30 miles. It is, in fact, known to extend 30 miles in the direction of its outcrop, and to be workable for a breadth of three miles, making 90 square miles, and probably very much more. As the slopes have been carried along the dip, there has been a perceptible increase in the thickness of the seams, and there are grounds to justify the view that their thickest parts will be in the centre of the basin. The beds have not been broken up, and have not suffered uplifts, and exhibit through the middle of the trough no outcrop of coal but only on the rim or outer edge of the basin. Deep River, on which this coal-field is situated, is a navigable stream.

Age and Equivalency of the Formation.

The age of a rock, or of a formation, is determined without difficulty, provided it contain fossils, or if its relations to other systems can be seen, whether those systems are above or below. But these sandstones and coal-seams rest upon a series of gold-bearing rocks, whose age dates back farther than any fossiliferous rocks, hence they cannot be employed for comparison. The only rocks which rest upon them are the sands of the Tertiary. We have, therefore, no way-boards by which their relations to other formations can be determined, excepting those of the most general character. The fossils are confined to one species of mollusca, which is only of the size of a grass-seed ; it is remarkable for its numbers; every layer or portion of the slate is crowded with them, and they range from the top to the bottom. It resembles a hay-seed, and is so numerous that thick layers are made up almost entirely of it.

These fossils indicate that the slates are of fresh-water formation, and that what had been a sea became a fresh-water lake. There are also the teeth of two or three saurians, and the scales and teeth of one or two fish. The vegetable fossils are few in number, and differ from those of the coal-rocks of Pennsylvania, or the flora of the Carboniferous age. The roots of vegetables in the fire-clay are thin, narrow, ribbon-like tissues. The meagre list of plants and animals, then deposited in the slates, furnishes only ground for conjecture as to what age the formation belongs. Prof. Emmons says, however, all the facts and circumstances then known inclined him to adopt the belief that it was the upper New Red Sandstone; still, if the Richmond coal-basin is of the same age as this, geologists will be disposed to place the series along with the oolites or Lias.

A single trap-dike traverses the entire formation from the southwest toward the northwest, and appears at numerous points along the line. Prof. Emmons, in his report of 1852, expressed the opinion that the Deep River coal-basin belonged to the Triassic age, or New Red Sandstone, and this is now the received opinion. But in his final report, in 1856, he argues that it is Permian. In this, his later report, he says the coal-measures of Deep River form a distinct belt, consisting of two principal rocks, the drab and gray sandstones, and the coal-

slates or shales, and these lie between two red sandstones. There are five seams of coal; the first or upper one is the most important, and is six and a half feet, consisting of two seams separated by a valuable seam of black-band iron-ore. The fire-clays below the coal-seams are quite common. They are traversed vertically by organic remains, but contain an entirely different series of vegetables from those of the older coal-fields; stems of sigillariæ or stigmaria being unknown.

There is a seam of anthracite at the Gulf, and one of semi-bituminous at Evans's mills, both these being near a heavy trap-dike, which apparently accounts for the condition of the coal.

As to the extent of the Deep River coal-basin, Prof. Emmons states, in this report, that he had traced it from Oxford, in Granville County, across the State in a southwest direction. It passes into South Carolina six or seven miles, where it terminates. In North Carolina its length is about 120 miles. Its breadth is variable. At Oxford, its northern termination, it runs to a point. The widest part is 18 miles, between Raleigh and Chapel Hill. On the Neuse it is 12 miles. On the Cape Fear, between Jones's Falls and the Buckhorn, it scarcely exceeds six miles. This is one of the narrowest points, as it widens rapidly in a northeast and southwest direction.

The coal outcrop has been traced 30 or 40 miles in length. The probable extent of the coal-seams in the direction of the dip is uncertain.

ANALYSIS OF THE NORTH CAROLINA COALS.

	Volatile Matter.	Fixed Carbon.	Earthy Matter.	Specific Gravity.	
Farmville	30.91	50.70	18.38	1.416	
"	28.47	64.70	6.83	1.497	
" Lower Seam	30.85	63.90	5.25	1.415	
"	31.30	64.40	4.30	1.308	
Deep Pit (Egypt)	34.30	63.06	1.60		
				Moisture.	Sulphur.
Egypt, 1871 (Gruth)	25.75	63.27	10.14	.84	1.85
Gulf, " "	21.90	70.48	6.46	1.16	1.02

Walter R. Johnson, a distinguished geologist and chemist, visited the Deep River coal-region in 1849, and, in his "Researches on the Character and Practical Values of American Coals," he gives some additional particulars.

This basin lies partly in the county of Chatham, and partly in that of Moore, and is traversed longitudinally by the channel

of Deep River, a branch of the Cape Fear River. This coal-field, therefore, lies almost exactly in the centre of the State, and its northeastern extremity is about 75 miles by the course of the stream above the town of Fayetteville, to which, it is known, steamboat navigation reaches from the city of Wilmington. The Cape Fear and Deep Rivers were then about to be made navigable, by means of slack-water pools and locks, to the upper part of the coal-field.

The rock, which appears to constitute one of the lowest, if not the very lowest member of the coal-series, is a reddish-brown sandstone, and at various places it is interrupted by dikes of a dark-colored trap. At the edge of the coal-basin this red sandstone seems to repose on the upturned edges of the older slates belonging to the gold-region. It is a fact worthy of notice, that the older slates containing veins of auriferous quartz, the gneiss-rocks which border them, the coal-measures which overlie the latter, and the diluvial sands overlapping all, come into immediate contiguity within the limits of Moore County. The conglomerate quartzose pebbles, now reposing under and over the rocks of the coal-formation, appear to have been derived from the older slate-veins. We are assured also that particles of gold have been found among the sands in the very streams, and at the spot where the seams of coal are found. The beds of reddish clay, sand, and pebbles, may be seen at many points distinctly interstratified, and reposing on the older rocks, which are sometimes seen on their edge under the coal-rocks. In a westward direction the pebbles increase in size, and at length become bowlders, the quartz being in some cases cemented into conglomerate by clay and oxide of iron.

But for the extensive denudations caused by the Dan River and its tributaries, we might still be ignorant of the existence of the coal in this region.

The coal is found in and covered by a stratum of slate, and over this is another bed of red sandstone. The slate appears to be destitute of vegetable impressions, but is filled with minute bivalve-shells and interspersed with many coprolites of fishes or reptiles. In some of the laminæ of the slates are thin plates of carbonate of lime. As to the contemporaneousness of the bituminous, semi-bituminous, and anthracite beds

found in various parts of this coal-field of North Carolina, there can no longer be a doubt; and that the plumbaginous mass at the northeastern prolongation of the coal-formation, as well as the graphitous slate at the southwestern part, has had a similar origin, appears equally certain.

Singular Gradation in the Deep River Coals.

An attentive comparison, Prof. Johnson says, of the following analyses made by him, will prove that we have here added another to those cases of coal-fields which contain in different parts coals of widely-different constitution. We had previously the South Welsh coal-field, the Lehigh, Schuylkill, and Susquehanna coal-trough, the most southern of the Pennsylvania anthracite districts, the Belgium coal-field, and the coal-field of Eastern Virginia, which yields at the northeastern part the natural coke, a species of anthracite, and Barr's Deep River semi-bituminous coal, together with the Midlothian and Clover Hill coals of high bituminousness.

Besides going through all the gradations of coal, the North Carolina field evidently runs at both extremities into plumbago, associated with, and apparently produced by, the igneous rocks which have been injected into the coal-series, altering and tilting the strata, and in many cases disintegrating the sandstones and other materials. A few miles from Raleigh, toward the northeastern part of the coal-district, is found an extensive bed of graphite underlaid by a sandstone similar to that beneath the coal at Deep River, but giving signs of having been subjected to intense heat for a long period of time, developing certain metamorphic characters, such as the partial coalescing of the integral particles as if by incipient fusion. The following are the analyses of coals from five localities in this coal-field:

		Volatile Matter.	Fixed Carbon.	Earthy Matter.	Color of Ashes.	Specific Gravity.
1..	Ferish's, highly bituminous......	32.82	63.78	3.40	Salmon.......	1.318
2..	Horton's, semi-bituminous.......	23.63	72.57	3.80	Darker	1.311
3..	Wilcox's, Anthracite............	6.64	83.76	9.60	Reddish-gray..	1.549
4..	Chalmer's, Plumbaginous Slate...	11.16	10.35	78.49	Flesh-color....	Porous.
5..	Smith's, Plumbago..............	9.46	16.25	74.29	Silky lustre...	2.652

Horton's mine, or No. 2, is four miles higher up the river than Ferish's. This coal is used by blacksmiths, as its analysis

shows it might be, and Johnson gives the thickness of the seam at four or five feet. Two and a half miles southwestward from Horton's occur the anthracite coal-openings on Wilcox's land, No. 3. Six miles southwest of Horton's is the plumbaginous slate No. 4. It imbibes water rapidly, and its specific gravity could not be taken. Smith's plumbago, No. 5, is six miles from Raleigh. Here the materials of the coal appear to have passed beyond the anthracite state, and to have been converted into plumbago, which is used by the inhabitants for paint, crayons, pencils, and other purposes for which the same substance has been elsewhere employed. It is also exported by lead-pencil manufacturers. This coal has been known to exist in North Carolina nearly one hundred years, as Prof. Dennison Olmstead in 1824, in a report to the Legislature on the geology of the State, says it was then fifty years since the coal was first discovered. The census of 1870 makes no report of coal mined here.

Dan River Coal-Field.—(EMMONS.)

There is another coal-field in the northwestern part of North Carolina, in Rockingham and Stokes Counties, and extending into Virginia. Here a series of coal rocks has been known for a great many years as coal-bearing. These rocks are similar to those of Deep River, and consist of the same members; they lie in the same order, and have the same relations to each other as those of Chatham and Moore Counties on Deep River. The several tracts constitute a complete and perfect system, occupy a synclinal trough, and lie in the primary or stratified pyro-crystalline rocks. The direction of the trough is northeast and southwest; its axis may be defined by uniting Leakesville and Germantown by a line which would represent the direction of the coal-slates.

There are three of these small troughs, Deep River, Dan River, and Richmond, all formed in synclinal troughs of the primary system, and all lying with their axes parallel to the Atlantic coast. Each was evidently formed in a trough by itself, disconnected with each other; each was formed in the bosom of its own sea, and each remarkably deep. They never suffered by denudation or from great fractures, but are traversed

by moderately-sized trap-dikes. The Richmond coal-bed has been disturbed more than those of Dan River, and the Dan River lie inclined at a greater angle than those of Deep River. The heavy trap-dikes of Deep River and the minor ones of the Dan belong to one era; they all cut through the sandstones and slates, and send lateral branches of the once molten mass both between and upon the layers, baking and hardening those which are in contact or in proximity with them.

The conglomerate base is less perfect than at Deep River. The middle part of this formation of sandstone is occupied by a soft, marly slate, the coal-slate of the system differing in no respect from that of Deep River, bearing the same fossils in equal abundance through all the strata of which it is composed.

The coal-beds of Leakesville lie in these slates, two miles from the village, in a long ridge rising about 60 feet above the meadow which lies in the bend of the Dan. It appears that from Leakesville to Germantown coal is exposed at several points, being the extremes of the formation, besides its extension into Virginia. The entire thickness of the sandstone series is greater on the Dan than upon Deep River, but the attention given to the Dan River coal-field has as yet been too inconsiderable to develop its riches.

This Dan River coal-basin does not differ materially from that of Deep River. The seams of coal are less promising, however. The coal is semi-bituminous, or similar to Wilcox's. The system dips to the northwest; the angle of dip varies from 15° to 40°, and is usually greater than 20°.

The whole length of the field is about 40 miles, of which 30 are in North Carolina, the northeast extremity extending about 10 miles into Virginia. The breadth is not less than four and not greater than seven miles. It has no connection with the Deep River or the Richmond coal-field, nor with another small coal-field in Halifax County, Virginia. These four are all isolated troughs or depressions in the primary series, all with their axes in a southwest and northeast direction, which were never connected, and the intermediate parts removed by diluvial action, as there is no evidence of such action, and there is no drift proper, in North Carolina. But these troughs

were connected by the ocean. We are notified of our approach to them by the pebbly beds which bound and overlie the series. Considering their limits, their depth was very great, and they are but slightly disturbed, though they are traversed by trap-dikes. The Richmond trough is the most disturbed, the dip often exceeding 40°.

At Germantown, the extreme southwest extremity of the Dan River field, there are two seams of coal, each 18 inches, separated by one foot of slate. Impure semi-bituminous coal is also obtained two and five miles from that place, and at several other places toward Leakesville. At this place the seam is 3½ to 4 feet, and the coal is less valuable than on Dan River. The Dan River basin is considered less important than the Deep River;[1] there is less coal. The slates are equal in thickness, but the sandstones and conglomerates are thinner; and, in Virginia, the lower sandstones, with their conglomerates, are entirely wanting. The veins above the coal-slates are thicker, and there is no doubt of their identity.

This formation is deposited on the primary system; its age must depend on its fossils, which are very few, as there is no stratigraphical clew to base an opinion on. These red sandstones, like those of New Jersey and Connecticut Valley, it is well settled, were deposited between the close of the Carboniferous and the green sand. They are, therefore, either Permian, Triassic, Liassic, or Oolitic. W. B. Rogers, of the Virginia survey, makes their formation coincident with the Liassic of Europe, and Prof. Ebenezer Emmons, in 1856, calls it Permian, but, as before stated, it is now understood to be Triassic.

[1] *See* Supplement on page 680.

CRETACEOUS COAL.[1]

XXIX.

COAL-REGIONS OF THE ROCKY MOUNTAINS, IN COLORADO AND WYOMING TERRITORIES.

The limestones of the upper coal-measures are exposed at Omaha City, which is built upon the northwestern rim of the coal-measures as seen along the Missouri River. Near New Florence, these limestones are seen in the bottom of the river at very low water. At De Soto, 30 miles above Omaha, they pass from view, and they are not again seen, in going up the Missouri, from that point to the foot of the mountains. They cover only a small portion of Sarpy and Douglas Counties, in Nebraska, north of the Platte River, but they occupy a considerable portion of the State south of that river, and extend farther west in Kansas. Along the Platte River, for above eight miles, there are extensive quarries of limestone; and at the mouth of the Elkhorn River, at Papillon Station, 15 miles from Omaha, they dip gently toward the northwest, all traces of the coal-measure rocks have disappeared, and they do not reappear again until we reach the very margin of the mountains, over 500 miles to the westward. The cretaceous formation covers the surface for the next 85 miles, or to a point 100 miles west of Omaha; then occurs the White River group to the mountains west of Cheyenne.

Here, the question is inevitably asked, do not the carboniferous coal-beds extend westward under all these later rocks, or in other words—

[1] *See* Supplement on page 684.

Are the Newer Formations underlaid by Coal?

The inexperienced might readily adopt the idea that all those extensive regions of the world, and especially of the western parts of our own continent, whose surface is covered by these upper formations later than the carboniferous, must necessarily be underlaid by the latter, and therefore contain coal. If this were true, the great depth at which the coal would be found would generally be an insuperable difficulty in the way of its being produced, in the present state of the art of mining. But, in the next place, it should be understood that the geological series of formations may not be complete; for, although the strata of the earth's surface were formed in the regular succession described by geologists, yet they are not, as Werner taught, equally spread over it like the coats of an onion. Examples have already been given, where many members are entirely wanting, from the absence of the conditions necessary for their formation. If the surface of the earth were uneven, the water not being of very great depth, and parts of the earth being dry land, the sedimentary rocks, which can only be formed under water, would only extend to the shore, and be wanting over the parts which were islands or continents during the age when they were being formed, and in places too remote from the producing causes. To those who are not familiar with geological subjects, it may seem very strange, for example, that Southeastern Pennsylvania, while it has no coal, has running across it a belt of a much later formation, the Mesozoic, or New Red Sandstone of the Triassic period (*see* small map on page 185). The same New Red Sandstone extends across the State of New Jersey, and as far south as South Carolina. It is found in the valley of the Connecticut River, and furnishes the brown building-stone used in New York City. It covers the battle-field of Gettysburg, and there, the next adjoining formation below it is the Potsdam sandstone, of the South Mountain. Here all the intermediate formations, including the carboniferous, are wanting. This Mesozoic formation is frequently traversed by curious trap-dikes. The Palisades on the Hudson River, and the same ridge in Jersey City, through which the tunnel and deep railroad-cuts pass, are composed of one of these trap-dikes

in the New Red Sandstone, and there is no coal under them, although both are a later formation than the coal-fields of Pennsylvania. When the Alleghany Mountains were elevated, a deep gulf was formed east of that range of mountains, which was afterward filled by this Mesozoic or red sandstone. An equally remarkable absence of many of the great geological formations exists on a much larger scale, throughout that vast region between the Missouri River and the Rocky Mountains, and through New Mexico and Colorado. The upheavals of the granite mountains have turned up and exposed the edges of the formations, showing the highest to be the White River Tertiary, and the next below are the Transition of Hayden, the latter containing, as before stated, lignite beds of great value. Next below, are the Cretaceous, then the Jurassic and Red beds, then the Carboniferous, which in these Western Territories is altogether of marine origin, and contains no coal; below it all the Devonian and Silurian formations are entirely wanting, or at least have not yet been discovered, except the lowest or Potsdam sandstone, below which are the granite, metamorphic, and basaltic rocks.

Profs. Hayden, Newberry, Foster, Blake, and others of our best geologists, who have explored the country from the Missouri to the Rocky Mountains, have all asserted, in the most positive manner, that no coal whatever of the Carboniferous age has been found, and that there is every reason to suppose that none exists much farther west than Fort Riley, in Kansas. The carboniferous rocks exist, but they belong to the upper carboniferous, above the true coal-beds, and being of marine, instead of fresh-water origin, no workable beds of coal need be looked for. Colonel J. W. Foster, a high geological authority, says: "While the carboniferous limestones, and even those of the coal-measures, have been observed at frequent intervals along the entire eastern slope of the Rocky Mountains, there is not to be discovered, in all that region, a true seam of coal of the Carboniferous epoch, and the reason for this is he thinks obvious, because to the east the waters were shoaling, giving origin to a series of lagoons, on which flourished the rank, luxuriant vegetation of the coal era. While such conditions existed to the East, he says, on the other hand, to the West stretched out

a deep ocean with no visible shores, whose waters were tenanted only by marine forms, and upon whose floors only limestone sediments were deposited."

We have referred to the varying thickness of the rocks according to the vicinity to the producing causes or forces. Some formations require special circumstances for their production, such as coral limestone, to form which a depth of water not exceeding 100 feet is necessary, and a uniform temperature of not lower than 68°, and the absence of muddy or cold currents. In like manner, many very peculiar conditions were necessary for the formation of coal and for its transformation, as is explained in the chapter describing the origin of coal. The coal-plants are of the fresh-water species, while the coal-measures in these Western regions are found to be represented by a purely marine deposit, such as carboniferous limestone, which, during the coal-forming ages, lay beneath the sea. While it would not be safe to predict that coal of the true Carboniferous age may never be found west of Kansas—for islands may be found in every sea—yet the indications seem to render that supposition highly probable. Then, too, if the true coal-measures are found on the western side of this continent, they may vary in thickness, and deteriorate in value, as they evidently do in a western direction, so far as they have been discovered. Unless we could be assured of something better than the poor kind of coal in beds from one to two feet thick found in Kansas, it would not pay to sink deep shafts, especially as there is plenty of lignite coal of a good quality near the surface.

In all the previous portion of this work, except Virginia and North Carolina, our researches have been exclusively in the carboniferous rocks, for in these alone are the valuable coal-seams of the eastern portion of the United States found. Probably only a small proportion of the coal now mined in the world is of any of the other ages. But now we have, as it were, passed into another world, where the surface is covered by newer and later rocks. The carboniferous rocks are not wanting; on the contrary, they are found in abundance and of great thickness. In the deep cañons of the Colorado and other rivers of the far West, and in numerous places where the

granite mountains have been uplifted, through the water-formed rocks tilting them upward and exposing them on the sides of the mountains, the carboniferous formations are always found. But there are two very remarkable peculiarities: first, that they rest upon the Potsdam sandstone, which in the East is the first fossiliferous rock above the primary system—all the usually succeeding Silurian and Devonian rocks are wanting in all the region north of the South Pass, latitude 42° 31′ north—and, secondly, the carboniferous rocks produce no coal. Dr. Hayden thinks no workable beds will ever be discovered in formations older than the tertiary or cretaceous. "Over the area now occupied by the central and western portion of our continent the sea prevailed," says Prof. Newberry, "during the Carboniferous period, for there we find the carboniferous strata to be almost exclusively represented by massive limestones, the organic sediments deposited in a broad but shallow ocean crowded with animal life." Hereafter, therefore, we are done with the carboniferous formation, for, as it produces no coal, we can take no interest in it. The fossil fuel found in the Western regions now to be considered belongs to the newer and higher systems of rocks, to which we must now devote our attention.

The general geological section in the far West is very brief. In the ascending order we have: 1. The granite or primary rocks; 2. The Potsdam sandstone, but this is sometimes wanting; 3. The carboniferous limestones, but without coal-seams; 4. The Triassic, a series of brick-red sandstones of the same formation as those seen between New York and Philadelphia; 5. Then a thin group of sand and marls, the Jurassic formation; 6. Then the whole series of cretaceous beds with their characteristic remains; 7. There appears to be a transition series between the cretaceous and tertiary, to which the coal-beds are now supposed to belong, or to the cretaceous; 8. The Tertiary; 9. Superficial deposits. All these rocks are tilted upward in the elevation of the mountains, up to the light-colored rocks at Cheyenne, which were deposited subsequent to the uplifting of the mountain-ranges. The Triassic is the formation in which in certain localities, from the existence of dry land to produce the necessary vegetation, some of the smaller coal-regions owe their origin, such as those of Richmond, Virginia,

Deep River and Dan River, North Carolina, and Los Bronces, in Sonora. But in our Western Territories there is no coal of this age, although the triassic rocks are abundant.

Lignite.—Scientifically speaking, there is no more coal west of Kansas, thereby meaning that better quality of fossil fuel found among rocks of the Carboniferous age, but, practically and commercially, there is a great abundance of it, such as it is. That which is found in the same form, is mined from the earth in the same manner, has the appearance and answers the useful purposes of coal, is deserving the name of coal in common parlance. As a convenient distinction, expressive of its geological age and peculiar qualities, however, it is more accurately called lignite.

The lignite formation is easily distinguished from the coal-measures, as well by its distribution and the chemical compounds of its combustible matter as by the plants by which it is accompanied. Lignites are formed by the accidental deposition of a certain quantity of wood, apparently transported by rivers or some other agency; or even, perhaps, are composed of the heaped remains of trees which grew in marshes and swamps, at the places where beds of lignite are now found. The areas which they cover with strata of combustible matter are extremely variable. Sometimes they extend themselves for hundreds of miles, preserving a certain horizon; sometimes they have only a few feet in diameter, and appear either thin or like a broken and heaped compound of black combustible matter, irregularly placed at various horizons in the same vicinity. Beds of lignites are generally intermixed with clay or sand. Their overlying strata often are not shales, but mostly soft, black, or yellow, plastic clay or sand. The numerous remains of plants found in this soft matter are, of course, decayed, broken, and undistinguishable. Sometimes the lignite is a compound of pure combustible matter, much softer than stone-coal, or true coal, and sometimes it is composed of alternate layers of soft clay, with bands of pure lignite from one to two inches thick.

All the fossil-leaves in lignite beds in the Tertiary recall forms which we are in the habit of seeing around us on the trees of our time, such as oaks, walnuts, and beeches, elms and

others, easily recognized by the branching of the veins. On the other hand, the fossil leaves of the true coal are mostly ferns, and the other remains represent the scars or the striæ of the bark of trees, of which the form, the direction, and the remarkable regularity, are entirely at variance with the rough and irregular surface of the bark of our trees.—(Owen, in Arkansas Report.)

Brown coals are more subject to spontaneous combustion than the true coals. Those which extend many hundreds of miles along the Upper Missouri River were observed, by Lewis and Clark in 1804, and by subsequent travellers for a long time afterward, to be on fire in numerous places on the borders of the great rivers. Occasionally they are now found on fire. The same phenomenon prevails in Australia in coal of the like age. In our Western Territories many extensive beds of these lignites have been evidently entirely consumed in the ground from spontaneous combustion, leaving a layer of ashes where was once a seam of coal. The adjoining rocks are partially melted, or otherwise metamorphosed, according to the nature of the material of which they were composed, and the degree of heat. In some instances overlying beds of clay, within reach of the heat, have been burnt into a brick-like material.

During the Cretaceous and early Tertiary periods an immense swamp seems to have existed along the foot of the Rocky Mountains, on the eastern side, extending for many hundred miles northward into British America, along the waters of Mackenzie's River to the Arctic Sea, along the coast in Alaska, and southward into New Mexico. A similar formation is found at intervals all along the coast of South America, producing lignite coal, which is found as far south as Patagonia, along the straits of Magellan. R. C. Taylor, in his statistics of coal, published in 1848, gives an account of this wonderful deposit, with a good chart of the coal-fields on the surface of the globe, on which these and the lignite fields of Europe and Asia are also given: "Throughout these regions, a rank vegetation must have flourished for a long period, of a much more modern character than that of the Carboniferous coal-measures, consisting largely of coniferous trees. In time an immense mass of vegetation was accumulated, which became covered by masses

of clay, sand, and pebbles, and thus these remarkable fields of Tertiary coal were formed with their coal-beds, under clays and iron-ores, bearing a great resemblance to the Carboniferous measures. On the west side of the mountains a similar condition of things seems to have existed, and coal-beds were formed, but changes of level caused the formation of a greater number of coal-beds of less thickness."—(Hollister.)

With the completion of the Pacific Railroad, and the prospective settlement of the vast region, wholly destitute of timber, through which it passes, the question of fuel for this and other railroads, and for the population which will occupy this great country, arises as one of momentous importance. Some of the first geologists of the country, and especially Dr. F. V. Hayden, who is the best authority in regard to that region, have for years been exploring the country, long in advance of settlers, or almost of the hunters, generally accompanied by a force of United States soldiers, for their protection against the savages.

Whatever may be the extent of the lignite deposits of the far West, and there is no doubt they are immense, yet those localities where they are found of a good quality, near the great lines of railroad, are of the greatest importance. Indeed, the question of fuel along the line of these railroads is one on which their very existence, or the ability to operate them at any reasonable cost, greatly depends. The first of the completed lines of railroad, the Union Pacific, is very fortunately situated in this respect; for, although no coal is found for the first 656 miles west of Omaha, yet at that point a supply of coal of a sufficiently good quality for steam purposes occurs; and it is found at various other localities, from that place westward, 335 miles to Echo City, 991 miles from Omaha, and 785 from Sacramento. The following excellent account of these coal-regions, by the late Prof. James T. Hodge, is much the best, for the purposes of this work, that has been published, and is therefore given entire.

Numerous other mines have been opened since the date of Mr. Hodge's report, but his descriptions of the character of the coal, and the mode of its occurrence, will give the reader a correct general impression of this remarkable coal-region. As to its extent and boundaries, it would be premature to give any thing but very general statements.

THE COAL-MINES OF THE ROCKY MOUNTAINS.

"The occurrence of coal in the Rocky Mountains was observed and reported on by most of the early explorers on the different routes they traversed across the continent. Little importance, however, was attached to these discoveries; and, as the coal-beds were seen only in their outcrop, little knowledge was acquired of their real character. It was understood that they belonged, not to the true coal formation, but either to the Lower Tertiary or Upper Cretaceous, and the coal was consequently classed among the lignites, or brown coals, and generally considered to be far inferior in quality to the genuine coals of the Eastern and Middle States. As the country began to be settled, the scarcity of timber soon caused these deposits of fuel to be looked up, and mines of coal to be opened and worked in Utah and in Colorado. The construction of the Union Pacific and Central Pacific Railroads created a still greater demand for fuel for the supply of their locomotives; and new mines were opened along the line of the former road in Wyoming Territory, which, with those worked on the eastern border of Utah, near the same road, supply both these long lines of road with all the coal they require. No mines have been found near the Central Pacific Railroad, either in Utah, Nevada, or California; so that this road is wholly dependent for fuel upon the coals brought to it from the Union Pacific. Though it is scarcely three years since these coal-mines began to be developed, they have already produced large quantities of coal, and several among them have the appearance of thriving collieries, well furnished with powerful machinery for pumping and hoisting, and all the appliances of first-class establishments.

"In Colorado, mines were opened along the eastern base of the Rocky Mountains about eight years since, and a number of them have been worked to a moderate extent from that time, supplying Denver and the settlements below the mountains. The coal was found very serviceable for domestic purposes; but was deficient in calorific qualities, such as are required for founderies and other metallurgical works. The writer, in 1863, found the blacksmiths for the most part unable to produce a welding-heat with the coal in their forges, and coke was brought from Kansas for a foundery at Black Hawk, at an expense of $160

per ton. The coal-mines were then esteemed of very little value. The opening of the Kansas Pacific Railroad to Denver, of the Denver Pacific to Cheyenne, and of the Colorado Central from Denver to Golden City, with the prospect of its extension in another year to the mining towns in the mountains, has greatly added to the importance of these mines, and led to arrangements for working them upon a large scale. In September and October, 1870, the writer again examined them, and also visited all the coal-mines of importance in Wyoming and in Utah, near the Union Pacific road; and the following are some of the results of his investigations, and of the analyses he has made of the coals he collected:"

The Geological Formation.

"All these coal-mines are found in a series of sandstones and fire-clay, probably of Lower Tertiary age.[1] No limestones occur with these strata, and black slate is met with in small quantity only. The sandstones are generally somewhat friable in texture, and are often exposed in bold cliffs, the faces of which have weathered in very irregular shapes, and frequently present deep holes and cavernous depressions. Its color is from a light yellowish to reddish brown, and sometimes gray. In places, it is sufficiently sound and firm to make a good building-stone. The fossils it contains are chiefly leaves of deciduous trees. No ferns and other fossil-plants are found in the formation like those common to the true coal-measures. The black slates, forming the roof of a coal-bed at one locality in Wyoming Territory, are found filled with fossil unios, which, as the writer is informed by Dr. J. S. Newberry, are probably an undescribed species. Fire-clay is perhaps the predominant material of the formation. It occurs in beds of great thickness, especially in Colorado; and at Golden City it is manufactured into fire-bricks of excellent quality. Clay iron-stone is occasionally interstratified with the clays and black shales; and in Boulder County, Colorado, the summits and sides of some of the hills near the coal-mines are partially covered with masses of brown iron-ore, that have the appearance of solid ledges; but which were no

[1] By Dr. Hayden's report of 1871, they appear to be Cretaceous, or a transition series between the Cretaceous and Tertiary.

doubt collections of clay iron-stone, left behind when the lighter materials of the strata containing them were removed, and converted subsequently by atmospheric agency, into those brown hydrates."

The Coal-Seams.

"The coal-beds are often of great size, the largest now worked being 26 or 27 feet thick. This is on Bear River, on the eastern border of Utah. For the most part they are remarkably free from impurities, it being not rare to see a face of eight or even 10 feet of clean coal of brilliant lustre, perfectly sound and solid in the mine, without a particle of slate or any visible foreign matter that would injure it. Iron pyrites, however, may generally be detected in small flakes and thin disks; but very rarely in sufficient quantity to be injurious. Mineral resin is a common ingredient of the Colorado coals, and was met with at one of the mines only on the Union Pacific Railroad, that at Carbon. The beds lie at an angle with the horizon; some are vertical, none were observed level."

Qualities of the Coal.

"All the coals tend to crumble soon after being exposed to the weather; but when protected they remain a long time unchanged, as is shown by a large lump in the possession of the writer, which he obtained at a mine in Boulder County, Colorado, in 1863, and which is still sound. This tendency to crumble is the cause of great waste at the mines—all the greater, that these tertiary coals can scarcely ever be made to melt and agglutinate into a firm coke. With rare exception, when submitted to the coking process, they retain their form, or crumble into a dry powder. As seen by their analysis, they all contain water in their composition; and this is very slowly given up even at the boiling temperature. Its presence necessarily detracts from the calorific power of the coals, not merely by reason of the water taking the place of so much carbon, but by the consumption of more to produce the heat required to expel this water. Hence, it is difficult to obtain a strong concentrated heat, such as is needed for welding iron in the forge-fire; and it is only by particular care and skill that the blacksmiths have

generally succeeded in making it answer their purposes. At the machine-shops of the Union Pacific Railroad it is not yet admitted as a substitute for Eastern bituminous coals, though some of these are brought from Pennsylvania mines, about 2,000 miles distant,[1] and the very best of the Rocky Mountain coals are obtained directly on the line of the railroad. As a fuel for locomotives and for domestic purposes, including cooking as well as warming, the coal in general answers very well. It kindles and burns freely, making a bright fire with a yellow blaze and comparatively little smoke. The odor of this is not so strong or disagreeable as that of the bituminous coals, and somewhat resembles the smell of burning peat. The smoke is not always dark and thick, but is sometimes of light-gray color. The ashes are remarkably light and bulky. The engineers of the locomotives find that some varieties crumble more than others in the fire, and sift through the grate-bars. These require closer screens at the top of the smoke-stacks. They endeavor to obtain the coal as freshly mined as possible, on account of its sounder condition. Clinkers sometimes form sufficiently to be troublesome, when the coals are obtained from those mines that contain seams of slate. There have been a few cases of combustion of refuse heaps of coal, supposed to have occurred spontaneously. The presence of iron pyrites, in coals so easy to crumble and ignite as these, cannot fail to suggest this danger, and the importance of guarding all heaps of it from becoming wet. It is not unusual in the Rocky Mountain region to meet, among the strata of sandstones, beds of ashes, which are evidently the ruins of coal-beds, some of which are of large size. The writer has seen many such in the banks of the upper part of the Missouri River."

It is Lignite.

"The geological position of these coals, together with the considerable proportion of water in their composition, places them in the class of brown coals, or lignites, which are for the most part distinguished by their fibrous structure, and close resemblance to the wood from which they are derived. The

[1] The Union Pacific Railroad Company purchase, annually, at least 1,500 tons of Blossburg coal for blacksmithing, which is mined 1,740 miles east of Omaha.

braunkohle of the tertiary formations of Saxony and Brandenburg, when dug and stacked in the fields, looks more like brown logs of wood than like mineral coal. Other varieties are met with in various conditions of change, and among them some that closely resemble the ordinary bituminous coals in their compact texture, brilliant lustre, and black color, both of the coal and of its powder, thus differing entirely in appearance from the brown coals, or lignites, that give a name to the class. This is the general character of the coals of the Rocky Mountains; and their composition shows they are far superior in quality to what the name of the class would indicate. Indeed, they appear to be better than the best of the foreign coals of their own variety; and, as they present a wonderful degree of uniformity over extensive territories, it seems they are really entitled to an appropriate name that should distinguish them, not merely from the common bituminous coals, but from the other lignites also, to which they bear still less resemblance.

"The European lignite deposits are of very limited area, scattered here and there through Prussia, France, Great Britain, etc.; and in these small basins the composition of the fuel is very variable. In the Prussian provinces above named its value is rated at only one-third that of the genuine coals; while in the north of Ireland it is considered to be worth two-thirds as much as the bituminous coals. The weight of the ash in the published analyses for the most part exceeds 4 per cent., and ranges from this to 20 or 30 per cent., very rarely exceeding 40 per cent. The composition of the American varieties, so far as found by the writer, is contained in the following table, which also gives the localities of the principal mines worked and thickness of the beds. The water was determined by drying the coarsely-pulverized coal in an oil-bath, below the temperature of boiling oil, and above that of boiling water, continuing the drying for several hours till the coal ceased to lose weight. The fixed carbon in all these analyses is uncertain in quantity, as its amount varies through a few per cent. according to the greater or less heat employed in expelling the volatile matters.

ANALYSES OF COALS FROM THE ROCKY MOUNTAINS.

LOCALITY.	Miles from Cheyenne.	Thickness of bed, feet.	Specific Gravity.	Water.	Ash.	Volatile.	Fixed Carbon.	DESCRIPTION.
Golden City, C. T., 56 feet below surface	110 S.	6 to 10	1.33	13.43	3.85	37.15	45.57	Gray ash.
Golden City, C. T., north end of 100 feet level	....	6 to 10	1.354	13.67	4.00	34.75	47.58	
Do	....	6 to 10	.....	13.10	3.70	.....	.....	
Golden City, C. T., south end of 100 feet level	....	6 to 10	.....	12.70	4.10	.....	.....	
Murphy's, Ralston Creek, C. T.	105 S.	14 to 16	1.345	13.83	5.85	35.88	44.44	Orange-colored ash.
Do	....	....	.....	13.70	5.80	.....	.....	
Do	....	....	.....	13.90	4.30	.....	.....	
Marshall's Boulder Co., C. T.	96 S.	10	1.33	12.00	5.20	33.08	49.72	Gray ash; light, bulky.
Briggs's, Boulder Co., C. T.	84 S.	13	1.27	14.30	3.40	34.50	47.80	Orange-colored ash.
Baker's, Boulder Co., C. T.	86 S.	4½	1.32	15.00	3.85	30.50	50.65	Olive-brown ash; coal hard and tough.
Carbon, W. T.	140 W.	7	1.33	6.80	8.00	35.48	49.72	Light-gray ash; nearly white.
Hallville, W. T., upper bed.	233 W.	6	1.32	12.12	3.76	29.75	54.37	Gray ash; smoke whitish.
Hallvile, W. T., lower bed.	....	3	1.32	13.26	4.87	29.46	52.41	Yellowish-gray ash.
Van Dyke, W. T.	313 W.	4½	1.27	3.12	2.00	36.65	58.23	Light-gray ash; these coals make coke.
Rock Springs, W. T.	315 W.	9½	1.29	7.00	1.73	36.81	54.46	
Evanston, U. T.	442 W.	26	1.30	8.58	6.30	35.22	49.90	
Crissman's, Coalville, U. T.	480 W.	12	1.32	10.66	3.11	38.23	48.00	
Monte Diablo, Cal.	....	....	.....	3.28	4.71	47.05	44.90	By W. P. Blake, January, 1867.

"A table of the composition of some of the French and German lignites, most nearly resembling those of the Rocky Mountains, is given by Berthier, in his '*Traité des Essais par la Voie Sèche*,' vol. i., p. 312, and is here introduced for comparison. Those lignites, designated as 'common lignites,' are described in general terms as bearing a close resemblance to the coals of the secondary formations—black or brown in color—compact—of irregular fracture—often conchoidal and brilliant. Woody texture frequently very apparent. Specific gravity about 1.2. At the temperature of boiling water they commonly lose about 3 per cent. In the analysis given, the water thus obtained goes with the volatile matters in the second column. They do not generally melt by heat, but some of them soften sufficiently for the particles to adhere together; and some become fluid like oils at a moderate elevation of temperature. These last seem to belong altogether to fresh-water limestone formations, and to be nearly related to the petroleum found in the same formations:

DESCRIPTION OF THE LOCALITIES AND MINES ON THE KANSAS PACIFIC RAILROAD.

"COLORADO.—Coal has been found in Colorado, both on the east and west sides of the Platte River; but the only mines of importance are near the eastern foot of the easternmost or Blue Hills range of the mountains. The formation to which they belong is a series of sandstones and fire-clay, probably of Lower Tertiary age, which ranges north and south, and along its western margin is found uptilted in a vertical position, and sometimes dipping toward the metamorphic rocks, that make the steep mountain-slope, not half a mile distant. Farther away from the mountains the inclination is eastward, and so gentle that the coal-strata overspread large tracts of country. The formation follows the range of the mountains, north and south, to an undetermined extent; and coal is met with in it for more than a hundred miles from Denver in each direction; but the only mines of value, excepting a few to the south, are at Golden City, 15 miles west from Denver, and thence north for 10 to 15 miles into Boulder County, along the banks of the creeks that descend from the mountains eastward toward the Platte.

"GOLDEN CITY.—The first discoveries of coal at this place were several small and nearly vertical beds near together in the steep bank of Clear Creek, about half a mile below where it passes out from the mountains. These were followed but a short distance under the bank toward the south, when the extension of one of the beds in this direction was opened at the summit of the ridge a quarter of a mile from the creek. The bed was here found so large—from 10 to 14 feet thick—that

the lower workings were abandoned, and a vertical shaft was sunk on the hill, 100 feet deep in the coal-bed, and levels have been driven north and south from the bottom, and also 56 feet below the surface. The bed proved to be very irregular in thickness, sometimes pinching in to a few inches, and then expanding to 8 or 10 feet. Its average thickness is not probably more than 5 feet. A small steam-engine is used for pumping and hoisting. Little water, however, is encountered. A crosscut from the bottom, driven 70 feet east, penetrated the following strata: Clay, 4 feet thick; sandstone, 4; coal, 2; sandstone, 12; clay, 3; sandstone, 7; clay, 8; black slate, 3; clay, 4; sandstone, 3; clay, 2; coal, 2; clay, 8; coal, 2; sandstone, 6. The last stratum is probably the extension below of a heavy ledge of sandstone that forms the crest of the ridge. The clay is all fire-clay, of pretty uniform and excellent quality, very similar in appearance to that of the true coal-measures. It seems to be the prevailing material of the formation, and is used for the manufacture of fire-brick in an extensive manufactory at the base of the hill. The coal-mine has been worked only to the moderate extent of about 10 tons a day, for the supply chiefly of the local demand. The appearance of the coal, which is of a dull black, without the bright lustre common to the coals from the other mines, has operated unfavorably to its reputation in the Denver market, though no inferiority of quality is indicated by the analyses. It is obtained, too, in pieces of very irregular shape, quite unlike the handsome rectangular blocks of the other coals. Like them, however, it is almost entirely free from slate and iron pyrites. Resin occurs in it, in scattered particles and bunches, more abundantly than in the coals of the other mines. It may, perhaps, prove a better coal for gas than the other mines afford, which will soon be ascertained, if it has not been already at the new gas-works at Denver. The locality is very favorably situated for supplying the mining towns in the mountains with fuel, so soon as the railroad now in progress up the gorge of Clear Creek reaches them. The pine-woods there available have already been greatly thinned, and the question of the future supply of fuel would be a serious one, but for the supplies promised by these mines below the mountains.

"The range of the coal-belt to the north side of Clear Creek was traced by the writer in October last, and a point selected for trial-shafts on the hills half a mile from the creek. The line of these vertical beds is but poorly indicated on the surface, and may be easily missed. Faint streaks of coal-smut, or blossom, were in this instance followed to the depth of 70 feet in fire-clay, before they led to solid coal. The bed was here found about 10 feet thick. From this side of the creek the railroad will be most conveniently supplied.

"The outcrop of coal has been detected at intervals between Golden City and Ralston Creek, five miles to the north; and the formation evidently continues through; but no mines are worked in the intervening tracts.

"RALSTON CREEK.—Two large coal-beds are opened in the banks of this stream, five miles north from Golden, and about two miles below the foot of the mountain-range. They lie in a vertical position, about 25 feet apart. The upper or western one has been followed under the south bank some 30 feet, and was found to be about nine feet thick of good coal. But the other bed, proving to be quite as good as to quality of the coal, and affording in actual working full 14 feet free from slate and all foreign matters, it has been worked in preference. Other small beds have been met with farther up the stream; but these two are probably all of importance. The large bed is worked on both sides of the creek, and on the north side a large shaft was sunk the last season 60 feet deep in the coal, from the bottom of which levels are to be run north and south. The price paid for mining was $1.50 per ton—the coal run out by the miners, who found their own tools, powder, and lights. The timber required for stulls, etc., was provided by the owner from the mountains. Not so much of this is required in working a vertical bed as is needed in one inclined. But, on the other hand, the trouble, danger, and expense of working the former are essentially greater, and the amount of coal available over large areas materially less. In this case, estimating, with allowance for waste, that the production should average 12 feet of coal, and that a cubic yard of this weighs 2,000 pounds, the mine should afford, if worked to the depth of 200 yards and a mile in length, about 1,050,000 tons. The quantity ob-

tained, however, will depend very much upon the skill with which the work is conducted; and the freedom from accidents —especially fire, the danger of which has already been experienced. The coal appears very well, being of deep-black color, with brilliant lustre. It soon crumbles, however, on exposure, and the waste from fine coal in the mine has been so great that, if continued, a larger deduction would have to be made than that allowed in the above estimate. The coal has met with a ready sale at the mine at $4 per ton and $10 at Denver, 14 miles distant. The construction of the railroad to Golden must so reduce the cost of transportation that Denver will hereafter be supplied at lower rates.

"Half a mile south from Ralston Creek, toward Golden, coal was discovered some time ago, directly on the range of the bed worked, of which it is no doubt the continuation. The exploration thus made developed a large bed with a gentle dip toward the mountains. Whenever this is opened again it will be a matter of interest to trace out the extent of this change of dip.

"LEIDEN'S.—The next opening in the coal-bed to the north is in a gap through the sandstone ridge, about a mile and a half from Ralston Creek; and is known as Leiden's mine, from the name of the late owner, who, with two other men, lost their lives by entering the mine, last September, when the air was foul in consequence of its having been left unworked. It continued for some time inaccessible, and smoke was issuing from the entrance when the writer visited the place five days after the occurrence mentioned above. The locality is of interest as showing the continuity of coal. The formation is easily traced northward from this point, over a broad and highly-elevated open plateau, by the strata of sandstone projecting in vertical layers above the surface; and the coal can, without doubt, be found anywhere against the western edge of the strata, or in the depressions below the general level now occupied by ponds. The lands, however, are not likely to be soon occupied, the soil being filled and covered with small bowlders from the mountains—still, by irrigation, a considerable portion of them may be made productive; and the fact that several ditches are already made across these tracts, to the lower and

better lands to the east, shows that water is available even at their high levels. But the coal is more profitably obtained in the valleys of the creeks than in the elevated divides.

"In the next valley crossed by the belt, that of Coal Creek, some seven miles from Ralston Creek, another opening is met with under the western edge of the same sandstone ridge. The mine, however, is not now worked, the owners finding it more convenient to develop their other property near South Boulder Creek, two or three miles over the next divide to the north.

"MARSHALL'S (96 miles south of Cheyenne).—The mines in the valley of South Boulder Creek, known as Marshall's, are among the earliest worked in Colorado. They were in operation in 1863, and have continued without interruption to furnish coal to Denver, 22 miles distant, and to the neighboring settlements. The locality is a little to the south of the creek, in the hills bordering a small branch about two miles below the foot of the mountains. As many as four beds of coal have here been opened, two of which may, however, prove to be the same. One of them—the highest in the series—is found just under the summit of the divide, dipping gently toward the southeast. It is known as the Dabney bed—is said to be nine feet thick, and, when worked, furnished coal of a superior quality, especially for blacksmiths' use. At a lower level, and also lower in the formation, is found the main bed, which is worked to the thickness of 10 feet, through the whole of which the coal is remarkably clean and free from slate and other impurities. It contains very little pyrites in thin disks and some resin in small particles. In the mine the freshly-exposed face presents a beautifully brilliant appearance, and the coal is so sound that a cubical block of it, said to weigh over three tons, was taken out for exhibition at the fair in Denver. It is used very generally by the blacksmiths, who have overcome the difficulty they formerly experienced in not being able to get up a welding heat with it. The mine is worked by two parallel headings, or levels driven in from the north side of the hill, and rising a little up the slope of the bed. These extend about 600 feet in, and rooms are worked on each side, but chiefly up the slope. In the other direction the bed passes under a meadow, when the coal will have to be worked and drained by

means of vertical shafts. It is now mined for $1.25 per ton, besides cost of props and keeping the track, etc., in good condition.

"A third bed of coal, three feet thick, is found across the meadow just spoken of, in the hill to the east, not half a mile from the main bed. It dips eastwardly into the hill, and has been followed down the slope 60 or 70 feet, under a roof of fire-clay. This appears to lie between the Dabney and the main bed.

"The fourth bed is not far from the small bed just described, being a little to the north of a line connecting it with the mine now worked. It differs from the others in lying in a vertical position; and it is not clear where its position is in the series. A shaft was sunk upon the bed some years ago to the depth of 50 feet, and the coal was raised by a horse-whim. The bed was seven feet thick.

"A small blast-furnace was built at this place in 1863, for the purpose of working the brown hematite iron-ores found scattered about the hills in the vicinity. It ran but a short time, when the enterprise was abandoned. Though the coal-mines were so conveniently near, no attempts were made to use the coal; but pine-wood charcoal from the mountains was employed as fuel. The iron made was of superior quality, and it is evident from the appearance of the cinder-heap that the furnace, notwithstanding its diminutive size, must have worked well.

"WILSON'S.—From Marshall's, north, it is less than a mile over the plateau into the next depression, where the large coal-bed, easily traced by the outcrop of the sandstone ledge that overlies it, is again opened and worked. This place is known as Wilson's mine. The bed has been followed down the slope toward the south-southeast about 200 feet, and the height of the excavation in the coal is from six to seven feet. Probably the whole is not taken out. The coal itself is the same in appearance as that obtained at Marshall's.

"The continuation of the coal-bearing belt toward the north, here appears to be interrupted, as no more mines are opened in this direction. The general dip of the strata is with the slope of the surface toward the east, but somewhat steeper, so that the coal-beds are carried under and disappear. It seems,

however, that the dip must change, and a sharp uprise to the east take place, followed again by a long, gentle slope in the same direction, for the surface of the country appears to indicate this in the steepness of its short western slopes, and also the reappearance of large coal-beds some thirteen miles northeast of the last mine described. These are found in the side of a steep hill that ranges along the east side of Coal Creek, the same stream noticed before as being crossed by the coal-bearing belt near the mountain-range, and which below turns from an eastern to a northerly course.

"BRIGGS's (84 miles south of Cheyenne).—The most northern opening in these beds is that of the Messrs. Briggs. It is on the side of the hill facing the creek, and follows the slope of the bed into the hill east-northeast, the inclination not being so steep but one can walk easily down. The length of the heading is about 500 feet, and rooms have been worked to the right and left. No water has yet been encountered in quantity to be troublesome. The coal-bed is about 13 feet thick, including in this a seam of slate a foot and three inches thick at three to three and a half feet above the floor. The coal presents a handsome appearance, being of a bright glistening black, and coming out in sound blocks of rectangular fracture. It has been mined for the Denver market, 23 miles distant, and arrangements are now in progress for extending a branch of the Denver Pacific Railroad to the mine.

"BAKER's (86 miles south of Cheyenne).—The Baker or Douglas coal-bed is 3½ miles farther up the creek, toward the south, and on the same side of it with the Briggs bed. It lies about 200 feet lower down than this in the formation, as the extension of the latter is found at this greater elevation near by. The mine was originally opened in the bank of the creek, and, this being an inconvenient place to work it, an inclined shaft was started on the bench above and carried down through the overlying fire-clays and sandstone to the coal, when it followed the regular slope of the bed. A steam-engine is employed to hoist the coal and the water. The bed is 4½ to 5 feet thick, dips east into the hill, and produces a coal very different in appearance from that of the other mines. A part of it is of a dull jet black, hard and brittle, breaking in

cuboidal fragments, and streaks of this cannel-like character are seen in the more brilliant varieties that are also found. Iron pyrites in extremely thin disks, and resin also, are noticed in the coal. Two or three other small beds of coal appear in the bank of the creek; and in the slates or shales over them are courses of kidney iron-ore, that may possibly prove sufficient for the supply of a blast-furnace.

"Other coal-beds will doubtless be opened in this region, and also farther back toward the other mines. The only one discovered the last season was by Mr. Davidson, in exploring the strata near the highest elevation of the country, probably far above the great coal-bed. It proved to be a bed about 3½ feet thick."

2. *On the Union Pacific Railroad.*

"WYOMING TERRITORY.—Although the coal-belt of Colorado extends north into Wyoming Territory, and indications of coal have been found near the line of the Union Pacific Railroad, it has nowhere been found productive of good coal to the east of the Black Hills. Beyond this range of mountains, in the Laramie Valley, the same formation is again met with, and valuable mines of coal are worked at intervals near the road even to Salt Lake Valley.

"CARBON.—The first of these is at Carbon, a station 140 miles by the road from Cheyenne, which is at the east foot of the Black Hills. Here, by the side of the track, a large shaft has been sunk 70 feet deep down to a coal-bed seven feet thick; a steam-engine for pumping and hoisting is in operation, and all the appliances are provided in the way of good machinery and buildings of a first-class colliery. A considerable proportion of the coal used on the railroad is here obtained; and it is transported for sale to Omaha, 556 miles by railroad, and to Denver, 250 miles. The coal is in fair repute, though it makes some clinker, and the analysis shows it has more mineral impurity than the other coals. This comes in part from small seams of slate in the bed, and also from a coating of a white powder observed in the seams of the coal, which proves to be carbonate with a little sulphate of lime. If it contains more ash, it is, on the other hand, comparatively free from water, showing the

least percentage of this of any coal analyzed. The smoke of this coal is black, like that of the bituminous coals.

"HALLVILLE.—The next mining establishment is at Hallville, 142 miles farther west. Several coal-beds (probably four) are here found in a hill about 300 yards south from the railroad, and a side-track leads from this to the mine. The main bed of coal is from 5½ to 6 feet thick; and below it is another bed three feet thick, which in one place comes within a foot of it, and in others is separated from it by several feet of slates. Other irregularities of stratification are noticed in the main coal-bed itself, which near the entrance of the mine has in the lower half some small seams of slate, and near the roof a layer of bony, inferior coal, eight inches thick, none of which are found in the inner or extreme part of the workings. The coal itself is hard and solid, and burns with a white smoke, and little odor. The mine is worked without trouble from water, and the coal is drawn out on an iron track by mules.

"The black slate roof of the main bed abounds in fossil remains of fresh-water shells—unios of undescribed species. In the inner part of the mine, when the roof has been allowed to come down, many tons of these slates might be collected charged with the shells, still white, and often both valves preserved side by side. The brown sandstones interstratified with the coal-beds contain stems of trees converted into the same rock, and impressions of the leaves—all, however, very obscure.

"VAN DYKE.—The next coal-mine along the road is known as the Van Dyke, 30 miles farther west. This is in a hill on the north side of the railroad track, and so conveniently near to it that the coal is discharged by a shute from the mine directly into the cars. The bed is 4½ feet thick, entirely free from any admixture of foreign substance, except a trifling amount of iron pyrites in thin flakes in the seams, and dips gently to the northwest into the dry, barren hill in which it is found. The roof over it is remarkably smooth and sound, so that all the coal can be taken out clean, and comparatively few props are required for supporting it. This is an important consideration in a country so barren of trees as this Bitter Creek region. No water is met with in the mine, and the bed can apparently be followed over an extensive range northeast and

west without encountering any. The mine fronts upon the valley of Bitter Creek toward the south; and in the hills opposite it seems as if the same bed must again strike in.

"The Van Dyke coal and that of Rock Springs, two miles beyond, have the best reputation of any of the Rocky Mountain coals, and this by their analysis seems to be well deserved. These were the only coals that afforded any thing like coke by distillation; and they should give a more concentrated heat than any of the others, showing the best adaptation for metallurgical purposes.

"ROCK SPRINGS.—The mines known by this name are two miles west from the Van Dyke bed, and one mile east from the station of the same name. The coal of this locality has been obtained chiefly from a dry barren knoll of cavernous sandstone about 60 feet high, situated about 50 rods southeast from the railroad, with which it is connected by a branch track. On the south side—away from the railroad—the knoll ends abruptly in vertical cliffs; and in these, near the summit, are the outcrop of the coal-bed and the entrance to the mine. The slope of the strata is north-northwest, which carries the coal-bed under the main track of the railroad, and, as the knoll is now almost exhausted of coal, arrangements have been made for working the bed close to the main road, where also is the village of miners' houses. The bed is about 9½ feet thick, but only about seven feet are worked; for within two feet of the top is a thin seam of slate, that, with the coal above it, makes a better roof than the dry and crumbling slates and sandstones above would make. The coal, like the Van Dyke, is very sound and clean, igniting readily, and burning away entirely without crumbling in the fire. The smoke is black, like that of the bituminous coals. The mine is worked by contract—the miners riddling the coal in the mine, and delivering the lump-coal only outside for $1.25 per ton. The workmen have evidently been left to their own discretion, without any regard to obtaining the greatest amount of coal the mine should afford.

"The opening by the railroad track is a slope passing under Bitter Creek. This had not in October passed quite through the 'rusty' coal into the sounder part of the bed. The mine has to be provided with a steam-engine for pumping and hoist-

ing, and will, no doubt, be productive in large quantities of excellent coal.

"This vicinity, like most of the Bitter Creek Valley, is deficient in good water; so that, for about 60 miles east from Green River, this has to be brought, for the supply of the inhabitants and for the locomotives, in cars specially provided for the purpose, and making what is called the water-train. The cars, nine in number, have each two tanks about nine feet high and seven and a half feet average diameter, all of which are connected by a large hose. Following the water-cars is a box car, in which is a locomotive-boïler and a large steam-pump. By means of this the water is pumped into the stationary tanks at the stations, and into the barrels, casks, tubs, and even kettles and cooking-stove boilers, with which the inhabitants near the stations run, on the arrival of the train three times a week, to receive their supplies of water, paying for it at the rate of 25 cents a barrel.

"UTAH, EVANSTON.—The station of this name on the Union Pacific Railroad is 441 miles from Cheyenne, or 126 from Rock Springs. The mines are two miles northwest from the station across Bear River, in a hill on the north side of the fine wide valley of this stream. Seen from the mines this valley presents the appearance of a beautiful plain stretching out about four miles to the hills on the opposite side. Were the region less elevated, and the winters less severe, this would be a most attractive site for a large settlement. Bear River is a swift stream of good water, well stocked with large brook-trout. The Wahsatch Mountains, in view to the west, furnish pine-timber from their extensive forests. Building-stone of superior quality is quarried from the sandstone beds near the coal-mines, and clay-beds are worked for the manufacture of bricks at the foot of the hill.

"A branch railroad has been constructed to the mines, and is used for the benefit of both the Union Pacific and the Central Pacific Railroads, the former being supplied with coal by the Wyoming Coal Company, and the latter by the Rocky Mountain Coal Company, whose mines adjoin each other in the same coal-bed. This bed, which is nowhere exposed of its full thickness, is said to measure 26 or 27 feet from the floor to the roof.

It is evidently a bed of extraordinary size; but the workings are limited to the lower portion of it only, not more than eight or 10 feet being taken out. This is for the sake of greater convenience in getting the coal now required, and of economy in timber for props. It must be, however, at the probable sacrifice of all that is left, which is hardly likely ever to be recovered in good condition. The bed dips into the hill at an angle of about 15° with the horizon, becoming suddenly steeper at the lower end of the slope, which is already down over 1,000 feet in the mine of the Wyoming Company. Horizontal levels as long as the slope are driven each way from it, and many rooms worked. Many small seams of slate are seen in the bed, which, not being easily separated from the coal, must considerably impair its value. This damage would be overlooked in analyzing specimens of the coal, which would always be selected free from the slate. Iron pyrites is more abundant than in the coals of other mines, and it is stated that spontaneous combustion of a waste-heap has occurred, attributable, no doubt, to decomposition of the pyrites. The locomotive engineers complain that the coal does not burn up clean, and clinkers; still it is used by blacksmiths, who manage to get up a welding-heat with it. The arrangements for working the mines with powerful engines and machinery are those of extensive collieries, and the business is evidently bound to be large. The coal must be obtained in any desired quantity, and at the minimum of cost. The formation containing the coal-beds is obviously of the same period with that to which the Colorado coals belong.

"Coalville.—The Mormons have worked several coal-mines at this village and in the neighborhood, sending the coal to Salt Lake City, about 50 miles distant, by the old stage-road, and more recently to Corinna, on the Central Pacific Railroad. Coalville is five miles south from the Union Pacific Railroad at Echo Station, and this is 34 miles west from Evanston. At the village is Sprague's mine, which was not in operation last October (1870), and two miles up a narrow valley to the northeast is Robinson's mine, and immediately above this Crissman's mine. All these are apparently on the same bed of coal. Higher up in the hills are two other small beds, not worked. Robinson's and Crissman's mines are both opened in the bottom of a

ravine, and the former is supplied with a small steam-engine for hoisting the coal up the slope. The latter mine is entered by an adit level; and again farther up by a slope. The dip is to the northwest, and so gentle that a mule can haul a ton weight up the iron-covered track. The bed is from 11½ to 13 feet thick—all solid coal. The roof is sandstone, and not very secure, so that nearly the upper half of the coal-bed is left for safety, with the idea of some time taking it out. This makes a secure covering. Though the coal is very sound in the mine, and presents a handsome appearance after it is extracted, it soon crumbles on exposure to the air, and the railroad men do not speak well of it for locomotive use. It crumbles in the fire, and makes clinkers that melt and stick to the bars. Blacksmiths, however, use it satisfactorily. It is mined for $1.25 per ton, and sells for $2.50 on the ground. The bed must extend under large areas, which have not yet been explored for it. Its dip, if continued, would carry it under the sandstone cliffs of Echo Cañon."

Prof. J. P. Lesley's Comments on the Foregoing Report.

"We give Mr. Hodge's admirably clear and condensed report of the coal-beds, on which the future prosperity of the interior of the continent may be said to depend. Its value depends upon the perfect reliability of the author,[1] who has been known for more than thirty years to take a foremost rank in his profession as geologist, beginning with three years of the most conscientious and laborious study of the coals of Pennsylvania, as one of the assistants of Mr. Rogers on the State Survey, in 1837–'39. Scholars will also recognize in this report the disciplined pen of the author of a large number of articles on physical subjects in Appletons' "Cyclopedia," constituting in bulk a full volume of that series, and remarkable for the elegance and precision of their diction, and their exhaustive completeness. It is rarely the good fortune of the business world to find thus combined in one mind that integrity which seeks the absolute truth, skill and experience competent to discover it, and an intellectual discipline which alone can set it forth in all its simple clearness; generalized without becoming

[1] Mr. Hodge was drowned in Lake Ontario in 1871.

vague, and detailed without growing wearisome to the reader. We can only invite attention to a few of its statements:

"1. To the notable percentage of water in the coals, as shown in the table of analyses.

"2. To the vertical posture of the beds along the western margin of the field. This shows that the whole Missouri, Platte, Arkansas River basin country has slipped down eastward upon its foundation, the underground slope of the Rocky Mountains; a phenomenon of the Alps as described by the Austrian Imperial Geological Surveyors, and of the Himalayas as described by the geologists of the British Indian Survey; a phenomenon repeated along the eastern margin of the Cumberland Mountain bituminous coal-field in Western Virginia, where the fall-back has been westward, off the underground rock-slope of the Blue Ridge formations, and the horizontal coal-measures are suddenly turned up vertically at a right angle for hundreds of miles in length, and only a mile or two in width.

"3. To the evidences of fresh-water deposition of these Western coals, and also of their *shore* deposition; and as a consequence of this last, of their great irregularities in thickness, a 14-foot bed thinning, in a short drift, down to eight feet, and even to a few inches; making the most scientific mining necessary, and offering a serious warning to the people of those States, that they must not imagine that they have an exhaustless world of coal, but must hoard what they have with all their skill and care. Mr. Hodge's strictures upon the shocking and wicked waste going on in the magnificent 26-foot bed of the Evanston mines in Utah, would under any foreign government call out immediate preventive legislation.

"4. To the fact that, as in the case of the Golden Range Clear Creek coal-beds, a most discouraging and in fact almost invisible outcrop may conceal, at a depth of 50 or 100 feet, a bed of coal 10 feet or more in thickness.

"5. To the wonderful solidity and uniformity of some of these beds (once despised as lignites); their astonishing clearness and freedom from slate-seams, and ashy ingredients; and their portability on railroads, as in the case of the Marshall coal.

"6. To the real value of coal-measure iron-ores, once carbon-

ates, now hematites; once locked up in clay-strata, far above the present level of the surface, now released and covering the ground."

The following ultimate analyses of Western lignites were made in 1870 by Prof. Henry M. Smith, from hand-specimens furnished him by Prof. J. S. Newbury. They sufficiently determine the true position of these fuels among the coals:

No.	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Total Sulphur.	Sulphur as Sulphuric Acid.	Water.	Mineral Matter.[1]	Color of Ash.
1..	59.724	5.078	1.008	15.697	3.916	0.107	8.940	5.687	Dark red.
2..	64.842	4.336	1.283	15.518	1.602	trace.	9.415	2.999	White.
3..	69.840	3.897	1.982	10.990	.768	0.015	9.170	3.408	Gray.
4..	64.992	3.762	1.786	15.199	1.066	0.025	11.565	1.680	Yel'w brown.
5..	69.144	4.862	1.246	9.589	1.025	0.049	8.065	6.619	Pink.
6..	56.244	3.379	.420	21.815	.810	0.095	13.285	4.047	Dark brown.
7..	55.759	3.264	.608	19.004	.682	none.	16.520	4.183	Ochre.
8..	67.674	4.658	1.582	12.804	.920	none.	3.075	9.237	Pinkish.
9..	74.872	2.583	1.764	8.712	.727	trace.	8.190	6.052	Pink.
10..	84.103	.852	.280	2.187	.329	trace.	5.195	7.204	Gray.

LIGNITES: 1. Mount Diablo, California; 2. Weber River, Utah; 3. Echo Cañon, Utah; 4. Carbon Station, Wyoming; 5. Carbon Station, Wyoming; 6. Coos Bay, Oregon; 7. Alaska; 8. Alaska.
LIGNITIC ANTHRACITES: 9. Santa Fé, New Mexico; 10. Los Bronces, Sonora.

Prof. Persifer Frazier, Jr., in Dr. Hayden's report of 1871, estimates the coal-field which occurs on the east flank of the Rocky Mountains as 500 miles long in a north and south direction, and from the Black Hills to Weber Cañon, from east to west, as but little short of 500 miles. "Assuming that the eroding agencies have cut off one-half of the coal of this area, and taking one-half of the remainder of their average longitudinal extent, we have over 50,000 square miles of coal-lands. We have, however, good reason to suppose that the field extends northward into Canada, and southward with the Cordilleras. All this territory is omitted in this estimate of the extent of this coal-field." It is evidently premature to make any statement as to the extent, boundaries, or the precise geological age of these great deposits of lignites. Area furnishes at best a very deceptive idea of the importance and value of a coal-field.

Mr. Frazier describes the geological position of these coal-beds as between the upper cretaceous and lower tertiary, or in the transition-beds of Hayden, but Prof. Meeks's paleontology indicates them to be cretaceous. Nowhere in the world is there such a vast development of the recent coal-measures, and

[1] Mineral matter = Ash minus oxygen absorbed by the iron of the pyrites.

in few places is their existence more necessary to the advancement and improvement of the region in which they occur. They lie regularly, and in the main quite horizontally, although close to the mountain the beds are tilted.

In another part of the same report Prof. Hayden describes the fossils found in the mines at Carbon. "Just over the coal is an earthy bed of what the miners call slate, which breaks into slabs, showing a woody fibre, and much of it looks like charred wood or soft charcoal. A little higher up we find thin layers composed almost entirely of deciduous leaves, and above these come various kinds of clays and sands. Beneath the coal there are indurated clay and rocky strata, in which occur thousands of impressions of leaves, much like those of our common forest-trees, but belonging to species long since extinct. They are most perfectly preserved, and all plainly point to a period far back in the geological past, when these vast treeless regions of the present time were covered with dense forests, surpassing even those now growing in Ohio and Kentucky. Some of the layers of rock, two to four inches in thickness, are almost entirely made up of these leaves, and the condition in which they have been preserved shows that they must have fallen from trees that grew in the vicinity. Indeed, there is no doubt that for myriads of ages in the past, gigantic poplars, sycamores, lindens, oaks, and others, here spread their broad branches over the shores of some little streams or lakes, and shed their foliage in the shallow waters in the same manner as they do at the present day."

It will have been noticed that the coal-producing localities mentioned by Mr. Hodge, on the Kansas Pacific Railroad are east of the mountains, while on the Union Pacific Railroad, no workable coal occurs east of Carbon, which is 107 miles beyond Sherman, the summit of the mountain. The coal-deposits of Colorado, however, approach the road not far from Sherman and Laramie. Coal-seams and oil-bearing shale have also been found along the valley of Bitter Creek. Dr. Hayden relates that, during the progress of the excavation of the railroad near Rock Springs, the workmen built a fire by the side of one of the walls, and this oily earth ignited and burned for several days, giving light to the workmen by night, and filling the val-

ley with a dense smoke. He says the coal at Carbon is not confined to the neighborhood of the road, but crops out in many localities for 20 or 30 miles on either side, so that there is an abundant supply of fuel stored away for future use. As there is but a scant supply of wood or timber, and that at a distance of 20 to 40 miles, it is evident that the success of this great thoroughfare is entirely dependent on the supply of mineral fuel, and that its importance for all time to come cannot be too highly estimated. Along the railroad the Carbon coal-field extends west to St. Mary's Station, a distance of 25 miles, and east of that point beyond Carbon, in all about 50 miles. Also at almost every station from Bitter Creek to Rock Springs, 46 miles, coal-mines are opened, and an abundant supply for railroad purposes can be easily obtained. At one locality, near Point of Rocks, five beds were opened in the same bluff, with a vertical height of 80 feet; these beds were respectively five, one, four, three, and six and a half feet in thickness. Near the summit of the hill, just over the coal, is a seam of oyster-shells of an extinct species, six inches in thickness. Scattered all through the coal-strata are seams and concretionary masses of brown iron-ore, sometimes local and sometimes persistent over extended areas, occurring mostly in a nodular form. If the coal proves to possess sufficient heating power to smelt it, the ore must become eventually of immense economic value. The farthest points westward at which coal-beds have been found appear to be Echo City and Webber Station, 1,007 miles from Omaha.

Besides the more important localities above described along the lines of the railroads, coal has been found in numerous localities in Utah, where the principal mines now worked are at Coalville, in Summit County. In Sanpete an excellent quality of blacksmith-coal is obtained in unlimited quantities.

A branch of the Denver & Cheyenne Railroad, called the Boulder Valley Railroad, leads from Fort Upton 10 miles to the mines of the Erie Coal Company, where a considerable coal-business has been done. The Cañon City coal-field, also in Colorado Territory, promises to become very important on the Denver & Rio Grande Railroad.

In regard to the extent of these coal-deposits of the West,

Dr. Hayden says that, although they occupy an enormous area, yet the profitable deposits of coal lie in detached basins, some of which are quite restricted in their area.

Report of coal mined and shipped by the Wyoming Coal Company, in Wyoming Territory, on the Union Pacific Railroad, under the superintendence of Mr. Thomas Wardell:

	1868.	1869.	1870.	1871.
Carbon	6,560	30,428	51,519	31,687
Point of Rocks	1,830	5,426	.....	.....
Rock Springs	365	16,903	20,390	40,498
Evanston	.....	1,966	12,447	21,163
Total Tons	8,755	54,723	84,356	93,348

For further interesting accounts of numerous localities producing coal in Montana, Dakota, Wyoming, Colorado, Utah, Nevada, Arizona, and New Mexico, the reader is referred to the very able and valuable reports of Prof. Rossiter W. Raymond, United States Commissioner of Mineral Statistics. A large volume is published annually by the Government, consisting of his reports on the mining interests west of the Rocky Mountains. Although chiefly devoted to gold and silver mining, these volumes contain many notices of the coal-mines also, giving information to be found nowhere else, of which free use has been made in preparing this work.

XXX.

CALIFORNIA, OREGON, WASHINGTON, AND ALASKA.

The want of coal, that mainspring of modern progress, says Prof. Newberry, has been deeply felt by the inhabitants of California, and they have taken a great interest in the discovery of deposits of it within their own borders. The efforts, with this end in view, have been attended with but partial success. Beds of lignite have been found in various localities, which have served for a time to excite, and subsequently to disappoint the hopes of their discoverers. But, although the fact has frequently been announced in the journals, no true carboniferous coal has ever been found in California, Oregon, or anywhere along the Pacific coast, or in any of the Territories west of Kansas. Careful examinations have been made by the United States Government, by the Pacific Mail Companies, and others, of the numerous localities where coal was reported to exist, from Behring's Straits to those of Magellan, but they all proved to be lignite or tertiary coal, most of them of very little use except for burning lime and like purposes, even where they occur to some extent. There is no reason to believe that even one or more coal-basins may exist among the Coast-Range of mountains, as all geologists agree that, throughout all this western half of the North American Continent, no strata have been found older than the comparatively recent periods of the tertiary formation, resting immediately upon the hypogene or primary rocks, thus showing the remarkable fact of the total absence of the entire suite of sedimentary formations, from the tertiary down to the silurian, which form the surface of the more important portions of the United States east of the Mis-

sissippi River. As the carboniferous coal-formation has its place in the midst of them, it is of course wanting. From all the information that has been collected, it seems likely that the same geological features extend from Alaska, throughout the western coast of North and South America to Cape Horn.—(Tyson.)

The western coast of our country is really the New World, not only as regards its population, but also in its geological formations, and especially as to its coal. But what has been said above, the reader will understand as having reference only to that more valuable variety of coal which is found in England, in Pennsylvania, and other States, and which does not exist, or at least has not been found, on the Pacific coast. But there are extensive beds of other varieties of coal, differing, it is true, from the carboniferous, in their composition and heating qualities, just as the coals of other countries differ from each other. As coal of a poor quality is often found in the carboniferous formation, such as that of Missouri, Iowa, and Illinois, which are much inferior to that of Pennsylvania, so we are led to suppose from analogy, and from the discoveries already made along the Union Pacific Railroad, that coal may yet be found in abundance in portions of these extensive lignite-fields, of even a better quality than that referred to of our Western States. Researches in India, China, Australia, New Zealand, Chili, and on our Pacific coast, prove that good coal, adapted to nearly all purposes, is found outside of the carboniferous formation. Science has failed to demonstrate that good coal may not be found in the more recent geological formations. There are many reasons for believing that when the mines on this coast shall be worked to a depth approaching that of the mines in other countries, the quality of the coal will be found to bear a favorable comparison. Analyses of coal from the Mount Diablo mines in 1867, at a greater depth than the samples tested in 1861 and 1862, shortly after the mines were opened, exhibit a marked improvement, the proportion of moisture in the coal being much less in the recently-examined samples, increasing the heating power of the coal 25 per cent.—(Gabb).

The principal localities on the Pacific coast, where coal has

been produced, are the Mount Diablo region, near San Francisco, California; Coos Bay, in the southwest corner of Oregon; Seattle, on Puget Sound; Bellingham Bay, in the northwest corner of Washington Territory; and Vancouver's Island. The Mount Diablo mines are now the most productive of them all, the receipts from these mines at San Francisco in 1871 being 133,485 tons, besides smaller quantities shipped to Sacramento, Stockton, and other places, and used by the steamers and otherwise on the bays and elsewhere.

The situation of these mines on the fine navigable waters extending inland from San Francisco, which is admitted to be one of the finest harbors in the world, and the city itself the largest on the coast, with every advantage tending to make it one of the most important places of America, and the terminus of the first of our great Atlantic and Pacific Railroad routes, gives peculiar interest to these coal-mines, and fully justifies the somewhat extended and minute account of them which follows.

1. *Mount Diablo.*

The most eastern ridge of the Coast-Range, in stretching from the southward toward Suisan Bay, appears to lessen in altitude, until it unites with Mount Diablo, whose northern base nearly reaches the shores of the bay. This mountain, situated 28 miles nearly east of San Francisco, forms a prominent feature in the landscape, and its cloven summit is seen far and wide at points within the Sierra Nevada, as well as the intervening Sacramento Valley. Its summit is 3,960 feet high. The coal-mines are located on both sides of a high ridge or range of hills, which projects from the north and northeast sides of Mount Diablo. They are favorably situated for access to navigable waters, being about five miles or less south from the San Joaquin River, at a point where the water is deep enough for ships of 1,000 tons to approach the bank.

Coal was first discovered here in 1852, but none of the valuable mines were located until 1859, and several of the most productive have been located since 1860. The outcrop is traceable for five or six miles, trending easterly and westerly. The disturbed condition of the seams, in a part of the field, has caused the abandonment of some of the mines. The mines pro-

ducing coal in 1868 were the Black Diamond, Union, Pittsburg, Independent, and Eureka. The workings in some of them are extensive, some of the roads in one connecting with those of another, so that a person may travel a mile underground on the line of the seam. The deposit in this region consists of two seams in most of the mines, and in others three, the lower of four feet thick, known as the "Peacock" or "Cumberland;" the other of three feet thick, called the "Clark" vein, separated by about 300 feet in thickness of sandstones. They are named after the mines, in which they were first well explored.

The coal from the Union, Pittsburg, Independent, and Eureka mines is carried on the Pittsburg Coal Railroad, which was completed in February, 1866, and is only 5½ miles in length, with an inclined plane, with good machinery. From the mines to the plane, 1½ miles, the grade of the track is 274½ feet to the mile, and the four miles from the foot of the plane to the river, the grades are from 40 to 160 feet to the mile. There are eight trestle-works, the most extensive of which is 340 feet long; there is a tunnel 300 feet long, and a number of heavy banks and culverts, the gauge of the road is 4 feet 8½ inches, and its cost was $145,000. Side-tracks are constructed from each of the mines named to the railroad, and the coal is shifted from the cars to the vessels by shutes. It is estimated that the road can deliver 3,000 tons of coal daily on board vessels at the wharf.

The *Pittsburg mine* is worked by a slope cut at an angle of 30 degrees, by which the coal is reached at a distance of 350 feet. The coal is hoisted by a horizontal winding engine of sufficient power to raise 200 tons per day.

The *Union mine* is also worked by a slope, which in 1867 was 500 feet in length, having a vertical depth of 230 feet, the hoisting being done with an engine. The seam is the Clark or upper seam, and is three feet six inches in thickness.

The *Independent* is the lowest mine in the district; is worked by a perpendicular shaft 700 feet deep. Upward of $180,000 was expended for machinery, pumps, labor, etc., before the coal was reached. This mine is much troubled with water, and the pumping and hoisting machinery are powerful.

The *Eureka mine* is owned by the Independent company. The coal in this mine is obtained by means of an incline or slope 600 feet in length, at an angle of 45°, and is taken from three seams. The upper, or Clark seam, is three feet eight inches thick; the middle, two feet six inches, and the lower or Black Diamond, four feet. The two upper seams are passed through in reaching the lower one. The distance between the upper and lower varies from 225 to 350 feet.

There is another railroad, having no connection with the Pittsburg road above described, running from the Black Diamond mine to New York, on the San Joaquin River, where it is loaded into vessels for San Francisco and other places. The mouth of the mine is several hundred feet above the level of the plane. The coal is let down an inclined plane 900 feet in length, at an angle of 15°, the descending loaded cars drawing up the empty ones. The foot of the plane connects with a railroad over which the cars are hauled by a locomotive to New York.

This mine is operated on two levels; the upper one in the Black Diamond seam, by a tunnel 430 feet in length, cut through the sandstone which encloses the coal. The seam is four feet four inches thick.

The second level is 550 feet below the above, passing through the Clark seam, which is three feet six inches thick. This level extends 300 feet beyond, to the Black Diamond seam. The workings are quite extensive.

A third opening is being made which will strike the coal about 500 feet below both the other levels, and will cut the Clark and Black Diamond seams, and open up a large area of coal. Some smaller seams of coal are also passed through.

The construction of these two railroads has caused the suspension of some other mines which formerly did a considerable business by the slow and expensive transportation by teams, among which were the Central and Teutonia, the latter bearing several seams of coal, one of which is five feet thick.

The *Pacific mines* are operated by a shaft sunk six miles east of Somerville, on Marsh's ranch, which embraces the foothills at the base of Mount Diablo, and extending to the San Joaquin River. The shaft is 400 feet deep, and is several miles west of the disturbed formation in the Peacock and several

other abandoned mines. The Clark and middle seams are found dipping at an angle of 30°. The shaft and machinery are well constructed, and the company have leased 13,316 acres of land. A railroad carries the coal to the river. This shaft proves the regularity of the dip of this deposit over a large area.

All these mines thus clustered together about the steep, rugged mountain are described as presenting a singular appearance. The lofty chimneys of the steam-engines belching forth columns of dense-black smoke; the dark, dingy dwellings of the miners, and those who minister to their wants; the tall, trellis-like viaducts across the ravines over which the locomotives are constantly passing between the mines and the wharves; the clanking of the machinery, and busy hum of workmen and teamsters; the great black waste at the mouth of each mine, all tend to give a peculiar interest, if they do not impart much beauty to the scene. The distant view of the surrounding country, as seen from the ridge, embraces stretches of grassy meadows teeming with cattle and sheep; purple hills breaking in rugged outline against the sky, and glimpses of the San Joaquin meandering through its tule-banks dotted with the white sails of sloops and schooners, while here and there a neat cottage embosomed in orchards, and surrounded by yellow grain-fields, present a scene of quiet beauty suggestive of the progress of civilization.—(Min. Res., 1868.)

The coals of the Pacific coast, like all coals of the later geological formations, are soft, more or less friable, and contain considerable water. Compared with true carboniferous coal, such as Pennsylvania, or English, they give less heat, and the loss is far greater by breakage in handling.

The following are Prof. Whitney's analyses made in 1861–'62, and given in his Geological Report of California:

	MOUNT DIABLO.					Bellingham Bay.	Nanaimo, Vancouver's Island.	Coos Bay.
	Clark.	Black Diamond.	Cumberland.	Peacock.	Coral Hollow.			
Water	13.47	14.69	13.84	14.18	20.53	8.39	2.98	20.09
Volatile Matter	40.36	33.89	40.27	37.33	35.62	33.26	32.16	32.59
Fixed Carbon	40.65	46.84	44.92	44.55	36.35	45.69	46.31	41.98
Ash	5.52	4.58	0.97	3.94	7.50	12.66	18.55	5.34

Mount Diablo coal is not only extensively used in San Francisco, where more than 1,000,000 tons of it were received

within the last twelve years, but it is used almost exclusively by the river-ferry and coasting steamers, and by most of the stationary engines in San Francisco, and at places convenient to the rivers, particularly by the flouring-mills at various places. Considerable quantities are consumed at Sacramento and Stockton, and shipments are occasionally made to the Sandwich Islands, where it is used for running the engines on the sugar-plantations. The working of the mines has created several prosperous villages in the vicinity, among which are Somersville, Clayton, Nortonville, Pittsburg, Antioch, and New York.

2. *Coos Bay.*

Coos Bay is the leading seaport in Southern Oregon. Empire City, about four miles from its mouth, is the county-seat. The principal mineral wealth of the county thus far developed is found in its extensive coal-fields, which have been worked more or less steadily for the last 13 years, the mines having been opened in 1860. The bay is about 14 miles in length, and varying from 1½ to 2½ miles wide. The main part of it has a direction northeast by southwest, with a sharp bend to the north at the upper end of the bay. The Coos River rises some 30 miles inland, and enters the upper end of the bend. Four miles from the mouth of the river, in a densely-timbered and hilly country, is Marshfield, the centre of the coal-mining. There is a good entrance to the bay, and the bar at its mouth has 14 feet of water at high tide, and there is a Government light-house convenient. Four miles from the entrance of the bay, on the south shore, is Empire City, the seat of Coos County, a thriving little place.

The coal is found on the ridge that divides Coos Bay on the south from the Coquille River. The coal-deposit is composed of three adjoining seams enclosed in sandstone, dipping toward the southwest, at an angle of about 15 degrees. The two principal and lowest seams are each two feet and three inches in thickness, of uniform quality, and separated by an intercalated stratum of sandstone four inches thick, all of which are mined together. The upper seam, besides being of inferior quality, is only one foot thick, and is not removed by the miners, but

allowed to remain and support the roof, which is firm and easily sustained, making a thickness of 4½ feet of workable coal. The coal has a fine black color, with brilliant conchoidal fracture, is free from iron pyrites or sulphur, not liable to spontaneous combustion, and burns without the disagreeable odor so frequently accompanying coals of this nature, leaving but little ash. For a number of years it has commanded a better price in San Francisco than any other coal of the coast.

The deposit appears to be very extensive, being found at least 18 miles south of Coos Bay, and is very regular, and apparently free from faults and dislocations. The ravines and gulches which traverse the country are made by erosion, and do not affect the regularity of the coal-deposit, but give ready access to the coal. The distance from the wharf to the mouth of the Coos Bay Company's mines is only one mile. The loaded cars descend to the water's edge over a railroad of easy grade by force of gravity, and are returned to the mines by mules. Such is the purity of this coal that it requires no assorting, but is loaded directly on board ship as it issues from the mine, or else is stored, awaiting the arrival of a vessel. The coal is mined and delivered in the cars in the mine at a cost of $1, and the interior and exterior transportation is but 15 cents. The region is certainly remarkably favorably situated for economical working. The freight to San Francisco is $4.50, and the total cost of coal there about $7.—("Mineral Resources," 1870.)

The *Coos Bay* coal-field is interstratified with sandstone and shales, which form a series of several hundred feet in thickness, the strata being very much disturbed by intrusion of trap-rock, some of them being inclined at an angle of 45°. The beds of coal are found in the upper part of the series being more fully developed on the shores of the bay, where the strata are much less disturbed than near Cape Arago, at the entrance of Coos Bay. The fossils are evidently tertiary, and there is little doubt but the series as a whole is identical with that of the Columbia, which has been pronounced to be Miocene.

The most important seam varies considerably in thickness in different localities, its maximum being about nine feet. These beds of coal are said to extend over a large area in the

vicinity, and have been traced many miles inland. The coal is bright black and handsome, and when first mined has much the appearance of some of the bituminous coals of the Mississippi Valley, most resembling those from the coal-fields of Illinois and Iowa. Upon a close examination, however, it is readily seen to be tertiary lignite, most of it exhibiting very distinctly the structure of the wood from which it was formed. Masses of several hundred pounds' weight are seen, which were evidently portions of the carbonized trunks of trees of large size, in which the rings of annual growth knots and branches were almost as plainly perceptible as in recent wood. Like most of the lignites of the West, though firm when first mined, having a conchoidal fracture, upon exposure to the air for any length of time, it cracks up into a thousand cubical fragments. It burns freely, producing a bright, cheerful blaze and considerable heat, but is more flashy, and has far less heating power, than the best bituminous coal. Its analysis shows carbon 46.56, volatile matter 50.27, ashes 3.19. It contains apparently very little bisulphate of iron or other injurious impurities; the amount of gas is large, but of low illuminating power.—(J. S. Newberry.)

3. *Seattle.*

The Seattle coal-mines are located at a place of that name in King County, Washington Territory, and inland from the bay of Puget Sound about nine miles. There are five seams of coal, from four to twelve feet in thickness, which have been prospected on the surface over one mile, and the inclination of the strata is 35°. There is a tram-road from the mines to Lake Washington, where the coal-cars are transported across the lake on flat-boats to another tram-road leading to a wharf in Seattle. The port of Seattle is said to be the finest harbor on Puget Sound, free from all impediments, and perfectly safe at all seasons of the year. The depth of water at the docks is sufficient for the largest vessels. An analysis by Falkeneau and Hanks, of San Francisco, shows 45.97 of fixed carbon; 35.49 volatile matter; 6.44 of ashes; sulphur, 0.44, and water, 11.66.

4. *Bellingham Bay.*

Bellingham Bay is in almost the extreme northwestern corner of Washington Territory, and its mine is considered one of the largest and best on that side of the continent. The seam worked in 1867 is reported by Prof. W. M. Gabb as about 14 feet in thickness of coal and slate, of which about nine feet were available for mining. The coal, as compared with other coals of the coast, is of fair quality, the greatest drawback being the occasional presence of sulphur, rendering it unpleasant for domestic use. The position of the mine with reference to the harbor is excellent, the mouth of the mine being barely over a fourth of a mile from the vessels in the harbor, in which the coal is shipped. The seam dips at a high angle, and all the coals and the water in the mine have to be extracted by expensive machinery. About the year 1865 the coal took fire, rendering it necessary to flood the mine. It was reopened in 1867, and produced 20,284 tons, shipped to San Francisco in 1870.

The Northern Pacific Railroad, terminating at Puget Sound, will render the coal-mines in this region of increased importance. Bellingham Bay is 14 miles long and three miles wide, with a depth of water ranging from three to 20 fathoms. There is probably an extensive region underlaid with coal on the west side of the Cascade Range, and it is mined at various points between Willamette Valley and Bellingham Bay, the lowest seam being reported to be 16 feet thick.

Prof. Blake reports that coal from this vicinity was used in San Francisco as early as 1854, these being the first coal-mines opened on the Pacific coast. It was used for burning in grates and for cooking, and gave general satisfaction. It is a compact and perfectly black bituminous coal, breaking with a brilliant conchoidal surface, and in large masses, much resembling the carboniferous coal mined at Pittsburg, Pa. It burns freely, and leaves a fine white ash, which appears to be very abundant.

The only geological section of the district is furnished by Lieutenant W. P. Trowbridge, of the United States engineers, who examined the region in 1853. He reports that the coal-strata exposed in Bellingham Bay occur in a series of stratified rock, which dips at an angle of 70° from the horizon, and strike east 15° north.

The thickness of the series is about 2,000 feet, of which the coal-seams, which are nine in number, make an aggregate of 110 feet, the workable seams measuring respectively in the descending order, 20, 6, 6, 5, 12, 25, 5, 18 and 13 feet in thickness. Above the upper or 20-feet seam is 150 feet of sandstone, and the other seams are separated by bituminous shales, and six or seven heavy beds of sandstone and impure seams of coal not counted above, in the same order, measuring 540, 35, 25, 268, 14, 204, 200, 150, 220 and 15 feet, resting on a thickly-bedded sandstone.

The coal-beds enter the bank at right angles to the shore-line, and rise with a gradual slope to the height of about 350 feet, at the distance of about half a mile from the shore, when they are broken in a direction oblique to that of the beds, and fall off in abrupt ledges to their original level.

Prof. Blake suggests that some of the many distinct beds of coal described above may not be perfectly pure, being perhaps seams of bituminous shale or earthy matter, which in a rough and unworked outcrop might be considered good coal. The number and thickness of the beds, as given above, show, if it be correct, that the formation is very extensive and remarkable. It is not impossible, as suggested by him, as well as Prof. Newberry, that these beds of coal are so much plicated and disturbed, and stand at a high angle, that the same series is included more than once in the foregoing enumeration; an error sometimes committed, in disturbed regions, by the best geologists.

The officers of the United States Coast Survey report that this coal was used by them, that it produced a large amount of fluid slag, and it was necessary to rake the fire every twenty minutes, being inferior to the coal of Vancouver's Island, from the port of Nanimo, about eight or ten hours' run from Bellingham Bay. The latter coal is, however, also objected to on account of the great quantity of slag and cinder formed during its combustion. Prof. Blake says he observed that the amount of slag was unusually large, and that it ran down in streams from the grate-bars into the ash-pit, and could be drawn out into threads like glass.

As to its geological age, Prof. Newberry says the shales are

fossiliferous, and vegetable impressions at Bellingham Bay are particularly abundant, consisting for the most part of impressions of dicotyledonous leaves. The flora of Bellingham Bay is remarkably like that of the lignite-beds of the Upper Missouri, the genera being all represented on the Missouri, and some of the species are identical. The lignite-beds of the Missouri are undoubtedly Miocene, and it is very difficult to distinguish them from those of that age elsewhere. The analysis of the coal gives: fixed carbon, 47.63; bitumen, 50.22; and ashes, 2.15.

He also received fossils from the Nanimo mines, on Vancouver's Island, which were evidently derived from cretaceous rocks, and resemble those brought from the Upper Missouri by Mr. Meek and Dr. Hayden. The Miocene strata of the Upper Missouri are peculiarly characterized by beds of lignite, which have attracted the attention of every traveller who has passed up or down that river. Also, on the Lower Columbia, below the region covered by recent volcanic material, we find a series of Miocene deposits, which are also associated with great accumulations of carboniferous matter.

It is true that much of the lignite of the Pacific coast is more compact, approaches nearer to true coal, and furnishes a better fuel, than that of the Upper Missouri, but this is, doubtless, in a great degree due to the metamorphic action of eruptive rocks which have in so many places disturbed the Tertiary strata.

5. *Vancouver's Island.*[1]

The largest and southernmost island in the Northwest Archipelago of the Pacific is called Vancouver's Island, belonging to the British Government. Its greatest length, from northwest to southeast, is about 200 miles, and it is separated from the continent on the south and east by the arm of the sea called the Strait of Fuca. This strait extends from Cape Flattery directly eastward about 120 miles, and thence northwestward 250 miles, communicating with the ocean in the north through an entrance called Queen Charlotte's Sound. The southern part of the strait is about 40 miles wide. The part running northeast is in some places nearly as wide, but generally much narrower, and is filled with islands. Altogether, it is one of

[1] *See* Supplement on page 680.

the finest bodies of water in the world for navigation. At Nanaimo, on Vancouver's Island, about 70 miles above Victoria, there is a deposit of the same geological age as that at Bellingham Bay, and which has been extensively worked by the Vancouver's Island Coal Company. The appliances about the mine are reported by Prof. Gabb to be of the most substantial and convenient kind, and the working of the mine a model of good engineering. Prof. Newberry's analysis of the Vancouver's Island coal gives: carbon, 51.81; volatile matter, 44.30; and ashes, 3.89.

6. *Other Coal-producing Localities.*

The coal from a point 25 miles south of Cape Flattery is in all respects similar to that of Bellingham Bay and Coos Bay. Specimens cannot be distinguished, and its analysis is nearly identical, yielding carbon, 46.40; volatile matter, 50.67; and ashes, 2.93.

The Santa Clara California lignite resembles in its better portions the coal of Coos Bay; it is evident that, as a whole, it is decidedly inferior, as a fuel, to the coal from that locality.

Coal from Chili is sold in San Francisco. It is all derived from the Lota mine, and bears a very evident similarity to that of the Northwest coast. It apparently belongs to the same geological epoch, and indicates the extent of the area over which the Tertiary deposits are spread along the North and South American Pacific coasts.

A large amount of Australia coal is also sold in San Francisco. It has more of the laminated structure, the rhomboidal fracture, and general appearance, of the older coals; but, from its softness, and the evidently large amount of sulphuret of iron which it contains, it cannot claim the first rank as a fossil fuel.

The fossils brought from China, by Prof. Raphael Pumpelly, prove, rather unexpectedly, the vast coal-fields of that empire to be of Mesozoic age, carboniferous plants being entirely wanting. So large is this coal-bearing area, including both anthracite and bituminous coal, worked for hundreds of years, probably the oldest coal-mines in the world, that they quite overshadow the carboniferous coals of Europe and the Mississippi Valley, and suggest the question whether the name given

to the formation which includes the most important coal-strata has not been somewhat hastily chosen.

The reappearance, from such a far-distant point, of the fossil plants resembling well-known forms in America, is an interesting feature, and gives fresh evidence of the monotony of the vegetation of the globe previous to the introduction of the angiospermous forests of the Cretaceous period.

As San Francisco furnishes the principal market for coal on the Pacific coast, the annexed table of the receipts of coal from each locality will give a very good general idea of the rise and progress of the coal-trade, and of its distribution among the various mining regions. This table does not, however, give the full yield of all the mines, especially those of Mount Diablo, from which coal is also shipped to inland towns.

The preceding accounts have been given of the coal-regions on the Pacific coast that have been most productive. But it should be added that there is, besides these, a wonderfully large area underlaid by these lignite coals. The existence of coal along the Northwest coast of the Pacific has been known ever since the discovery of the country. The seams, cropping out in the face of nearly every bluff and promontory from Oregon to Sitka, are too conspicuous to have been overlooked. The extent of the coal formation on the Pacific coast is truly surprising.

Anthracite is known to exist at Skidegate Inlet, Queen Charlotte Islands, and a seam of the same kind of coal is seen cropping out on the main land opposite, about 40 miles distant. The extent of these deposits is not known, but specimens have been sent to San Francisco which were of good quality, and in 1871 there were 565 tons of it imported. From Cape Flattery to Admiralty Inlet, in Washington Territory, there is an almost continuous outcrop of coal. But for the want of a good harbor, it doubtless would have been developed.

From the above data it will be seen that the coal-deposits west of the Rocky Mountains, though yielding an inferior quality of coal, are quite extensive, and furnish such promise of improvement as to justify the hopes of the inhabitants that the supply will in time become sufficient for the demands of all branches of industry on the Pacific coast.

ANNUAL RECEIPTS OF COAL AT SAN FRANCISCO.

	Queen C. Islands.	Sitka.	Seattle.	Rocky Mountains.	Saghalien.	Puca Straits.	Mount Diablo.	Coos Bay.	Bellingham Bay.	Vancouver's Island.	Chili.	Sydney, Australia.	English.	Cumberland.	Anthracite.	Total.
1860...	...	....	......	......	....	....	....	8,145	5,490	6,695	1,900	7,850	6,640	5,970	39,965	77,685
1861...	....	...	......	....	....	....	6,690	4,690	10,055	6,475	12,495	28,870	23,565	2,976	26,060	116,245
1862...	....	....	......	...	....	....	22,400	2,515	10,050	8,870	5,110	19,590	16,055	4,970	34,685	121,545
1863...	....	....	......	......	....	....	48,900	1,165	7,750	6,745	1,790	16,890	14,660	5,670	33,660	135,550
1864...	....	....	......	......	....	....	50,700	1,200	11,845	12,785	2,898	21,160	13,880	7,275	41,650	167,298
1865...	....	....	......	......	....	....	60,530	1,500	14,446	18,181	1,410	17,610	9,655	4,290	22,055	150,147
1866...	....	....	......	......	....	....	64,090	2,190	11,330	10,658	1,460	58,700	7,400	9,524	12,124	192,601
1867...	....	....	......	......	216	599	109,490	5,415	8,599	14,889	14,949	26,619	7,309	12,177	46,018	248,925
1868...	....	....	......	......	204	....	132,587	10,594	18,864	23,848	8,511	81,590	30,561	2,399	29,562	282,025
1869...	....	....	......	......	....	....	148,722	14,524	20,558	14,830	1,114	75,115	17,396	11,596	24,844	328,978
1870...	....	....	......	......	....	....	129,761	20,567	14,255	12,640	7,850	88,969	31,196	9,299	21,890	330,496
1871...	565	18	4,918	1,095	....	....	182,455	28,630	28,284	15,631	4,161	83,949	54,191	6,060	7,281	315,194
1872...			14,830	1,349	....	....	177,298	22,548	4,160	26,008	3,698	115,352	29,190	10,051	19,615	424,457

7. *Alaska.*[1]

The most valuable of the geological formations of Alaska, from an economic point of view, is the Tertiary. In it are contained those beds of coal which have been so often reported on the northwest coast. The following is a list of the known localities up to the year 1870: Port Gardner, Hood Bay, Admiralty Island, good bituminous coal used by the United States ship Saginaw in 1868. Hamilton Harbor, on the east side of Kake Strait, a seam of good bituminous coal opened here in 1868; Kruznoff Bay, Admiralty Island, Kúiu Island, Kupriánoff Island, Port Camden, Kake Strait, a six-inch seam reported in hard rock with a southerly dip of 35°; St. John's Bay, Baránoff Island, fragments in débris of a glacier. Recent reports state that this seam has been discovered, and the coal successfully used on a United States steamer. Coal Harbor, Unga Island, examined by W. H. Dall, in 1865. The coal is of a poor quality, in thin seams, much mixed with slate and silicified wood, and is quite valueless; south coast of Alaska, black lignites, according to Erman; Cape Beaufort, Arctic coast, a small seam of true carboniferous coal; Akhún, coal reported by Lütké to occur here; Unalastka, near Captain's Harbor, small lignite seams according to Veniaminoff; Atka, lignite of poor quality found near Sand Bay; Amchitka lignite, according to Grewingk; Wrangell Harbor coal reported of good quality, by General Halleck; and, finally, Cook's Inlet.

In the latter locality are found the most promising deposits. North of Cape Starichkoff the coal is found in two parallel layers, which are variously reported as from 18 inches to seven feet in thickness, and are found from 36 to 60 feet below the top of the bank. Farther to the north, a third layer appears. They continue nearly to Cape Nenilchik, with a north-northeast dip, and appear again on the northern side of the cape, and then continue first with a south-southeast dip, and afterward horizontally, to the mouth of a small stream.

The coal of Alaska is Tertiary, and, like most Tertiary coals, is inferior to the Carboniferous coals both in quality and thickness of seams. The following table will show at a glance the comparative value and composition of the coals of the different

[1] "Alaska and its Resources," by W. H. Dall. Lee & Shepard, Boston, 1870.

formations on the west coast of America, and the best Carboniferous coals of Pennsylvania and England, and the superior quality of the Cook's Inlet coal, not only over the Miocene coals, but also over all the Cretaceous coals on the Pacific slope.

		Moisture	Fixed Carbon.	Volatile Matter.	Ash.	Sulphur.	Character.
Carboniferous.	Pittsburg, Pa.	2.34	55.32	34.81	7.16	....	Bituminous.
	Ormsby, Pa.	4.00	66.56	26.93	2.50	....	"
	Kentucky	2.00	56.01	37.89	4.10	....	Cannel.
	Lehigh, Pa.	2.34	88.05	2.94	6.66	....	Anthracite.
	Newcastle, England	0.99	61.70	33.55	3.75	0.23	Bituminous.
Cretaceous.	Nanimo, Vancouver's Island	2.98	46.31	32.16	18.55	....	Lignite.
	Bellingham Bay	8.39	45.59	33.26	12.66	....	"
	Mount Diablo, Cal.	14·69	46.84	33.89	4.58	....	"
Miocene Tertiary.	Coos Bay, Oregon	20.09	41.98	32.59	5.34	....	Lignite.
	Carbon, Pacific Railroad.	11.60	51.67	27.63	6.17	2.90	"
	Weber River, Pacific Railroad.	9.45	26.21	53.32	8.64	2.40	"
	Cook's Inlet, Alaska	1.25	49.89	39.87	7.82	1.20	"

The analyses of the Alaska coals were made by Prof. J. S. Newberry, of the Columbia School of Mines, New York, and State geologist of Ohio, who is excelled by none in his knowledge of the Tertiary coal-bearing deposits of the United States. He says this Cook's Inlet coal is fully equal to any found in the West coast, not excepting those of Vancouver's Island and Bellingham Bay. The very small amount of sulphur and moisture makes it, in these two important respects, equal to the best American coals.

Anthracite has been several times reported from various parts of Alaska. It is probable that the specimens collected may owe their quality to local metamorphism of the rocks by heat, rather than to the general character of any large deposits.

The value of coal is not due to its quality alone. Commercially speaking, a seam of coal, less than three feet thick of clear coal, is of very little value except for local use. The dip of the strata, its faults or foldings, the solid or crumbling character of the superincumbent strata, the distance from market, and the facilities for mining, shipping, and transportation, are all as important in determining the value of a deposit as the character of the coal itself. The existence of deposits of coal of permanent value in Alaska, though very probable, can only be determined by a thorough examination, and is yet to be proved.

XXXI.

NORTHWESTERN ONTARIO, OR CANADA.

In June, 1789, Sir Alexander Mackenzie left Fort Chippeway, on the Lake of the Hills, on his voyage to the Arctic, with all the difficulties before him of the first exploration in unknown, inhospitable regions, inhabited by savage tribes. His voyage through this vast northwestern part of our continent to the Arctic Ocean may be said to have first lifted the veil that, till then, shrouded the vast intervening regions in obscurity. He passed great plains of unknown extent, great tributaries of the river which afterward bore his name, half a mile in width, lofty mountains clad in snow or veiled in mist. He and his men looked upon the vast panorama that took week after week to unfold, for the first time since creation, to civilized man. They came to the region where eternal frost prevails under the surface; they arrived at the Esquimaux country and the open sea, and were astonished to see the tide, and that the sun did not set. Mackenzie returned to Fort Chippeway on the 12th September, having performed his voyage of 3,000 miles in 100 days. In returning, the air for some part of the way was laden with a heavy smell of sulphur, which was found to be caused by the burning of coal in the banks of the river. It was the lignite coal that is so abundant in this territory, and it is this circumstance alone that entitles his name and his voyage, or journey, to a place in these pages.

As this vast Northwestern lignite region is but an extension of that broad belt of this geological formation in our own country, extending along the eastern base of the Rocky Mountains, throughout their entire length, and northward to the Arctic Ocean, what is known of it in Canada may throw some light

upon its probable extent and value in our own Territories. True coal in the Carboniferous formation has never been discovered, and probably does not exist, in the Rocky Mountain region, although rocks of that age are abundantly displayed in positions admirably adapted for the examination of their contents, in the numerous deep cañons as well as the many upheavals of the strata, caused by the elevation of the granite mountains. As before explained, these carboniferous rocks are wholly of marine origin, and only correspond in age with the upper unproductive portion of those east of the Missouri River, but without the other necessary conditions required for the formation of beds of coal. A peat-bog cannot be possible in deep sea-water. There is, however, extending northward from the line of the United States, which runs at lat. 49° N., a region of lignite of surprising extent. The geological maps of the Hudson Bay Company represent, in the first place, a very large field of lignite extending northwestward, lying east from the head-waters of the Milk River, a branch of the Missouri. In form this first field bears a striking resemblance to a human leg, extending through eight degrees of latitude, the thigh being amputated by the United States line, the knee being well defined on the east side, about the 53d° and the point of the toe at 57°. It extends along the head-waters of the Saskatchewan River, which has numerous branches, such as its north and south branches, the Red River and Battle River. Thence it extends along and across the sources of Slave Lake, namely, the Pembina River, McLeod, Athabasca, Smoky or Peace River, and Hay River, which runs along the sole of its huge foot.

Thence along the west side of Mackenzie River, which flows from Slave Lake, there is another very long field of lignite extending from 59° to 60°, and three other smaller fields extending with but slight intervals to Mackenzie's Bay, at the mouth of the river. The same formation is represented as extending along the coast westward toward Alaska, as well as eastward of the mouth of the Mackenzie, and on the islands at its mouth.

The lignite is seen in many places in beds from two to eight feet thick, and no doubt extending over hundreds of miles. A few of the localities might be mentioned. Proceeding 30 miles northward from the United States boundary,

northwest of Fort Meade, a lignite-bed two feet thick is seen on Moose River. On the Red River branch of the South Saskatchewan it is in beds so close that, of 20 feet of strata, 12 feet were coal. It is also noted on the Battle River, to the northwest. On the North Saskatchewan the lignite prevails, with little interruption, in beds two and two and a half feet thick for 200 miles. Passing northward to the next stream, the Pembina, a fine navigable tributary of the Athabasca, a bed of lignite coal is exposed eight feet thick. On the Athabasca the coal appears in the banks, but not so much as on the Saskatchewan. On the former river the whole country for many miles is so full of bitumen that, if you dig a pit a few feet below the surface, it flows readily into it, and large deposits of sand are charged with it. Below the mouth of the Clear Water River lignite coal appears in pretty thick layers in the bank of the Athabasca. Proceeding to the next stream to the northward, the Peace River, coal is found on the Coal Creek. Also 150 miles farther south, beds of coal were discovered on fire. There are also beds of it on Lesser Slave Lake, a northern tributary of the Upper Athabasca. These points are 200 miles west from the lower course of the Athabasca, so that, at least, may be taken as the breadth of the country in which coal may be found.

As already mentioned, Mackenzie found coal-beds on fire on the banks of the Mackenzie River. Where Bear Lake joins it there is Tertiary coal of considerable extent; and finally, at the Garry Islands, lying off the mouth of the Mackenzie River, are beds of Tertiary coal that take fire spontaneously.

The authorities for the above are Mackenzie (1789), Richardson (1827), Dr. Hector, and other travellers. A full account of the resources of this country was compiled by Alexander J. Russel, a Government civil engineer, about the time the territory was bought by the Dominion of Canada, from the Hudson Bay Company in 1869, to which we are indebted for the facts given in this article.

From the description given by these travellers, it seems there is much variety in the character, quality, and condition of the lignite of this region. Some is of very recent formation, or yet being formed, like that of the vast deposits of drift-wood

in the conical hills at the mouth of the Mackenzie River. In some of the beds of lignite the forms of the trunks of trees are preserved. In others, composed of glance coal, the wood-like structure is lost, and pieces taken from the beds split into small rhomboidal fragments, no longer presenting the grain or layers of wood. Specimens of pitch-coal are found, resembling Spanish liquorice; and also of slaty coal from Edmonton, on the Saskatchewan, which Blackiston says is preferred to charcoal for smiths' work, though it is said to require rather a strong draught. In some cases the lignites are found heavily charged with bitumen, while others are much silicified.

Lignite, therefore, varies very much in quality. The lignite coal of Nanimo, in Vancouver's Island, is only 10 per cent. less valuable than coal of the Carboniferous epoch, according to Dr. Hector. The lignite in the region in question is estimated to be equal in heating power to five-sevenths of the same weight of Newcastle coal. And these statements are probably not too favorable, for, although the European lignites, by analysis, show a less calorific value, yet those found on the Union Pacific Railroad are superior to any lignites found in any other part of the world.

It is very evident that this lignite deposit prevails in immense quantities, and in positions where it can be most easily made available, in a climate where fuel will be much needed, and along navigable streams of great length, affording ready and very cheap transportation. Some of it is, no doubt, a poor quality of fuel, and much that is here called coal or lignite is probably dead wood and dry mud, and not capable of being used at all as fuel.

The accounts above given are derived from travellers who visited the country many years ago, and found these lignite-beds then on fire. The same phenomenon, as has already been mentioned, was very common in the Northwestern Territories of the United States, where vast bodies of lignite charged with sulphuret of iron are now found in a state of spontaneous combustion. Some beds were discovered by Dr. Hayden, along the Big Horn Mountains, in 1869, on fire, with considerable smoke, a strong sulphurous smell, and a heat so intense that persons could not stand within twenty feet from whence

the smoke issued. Other large tracts were found where beds of lignite had evidently been burnt out, burning the clay soil to a red-brick color, and melting the sandy rocks, as metamorphic rocks usually are changed by heat. Lewis and Clark observed these fires on the Upper Missouri River in 1804. These lignite-beds were not set on fire by Indians or hunters. They contained within themselves the elements of spontaneous combustion when exposed to the atmosphere, in the sulphuret of iron and water with which they abound. It seems the best of them are subject to burning in the ground, the others containing too much shale and earthy matter, separating it into thin layers, to ignite, and also rendering it useless as fuel.

The beds which Mackenzie visited in 1789, and found to be on fire, were reported by Dr. Richardson, who accompanied Captain Franklin's expedition of discovery in 1827, to be still burning.

When this far northern region becomes settled, portions of the lignite-beds which have not been wasted by spontaneous combustion may be found of a quality good enough for fuel for local consumption, but too high expectations mustnot be formed in regard to them, as they may prove to be scarcely more than mere objects of geological interest.

XXXII.

NOVA SCOTIA.

THERE has been no Government geological survey of the coal-region of Nova Scotia, but much has been published in regard to it, so that there is no lack of information about it accessible to every one. The largest and best work on the subject is by John W. Dawson, a very distinguished geologist. Its title is "Acadian Geology," and the second edition, published in 1868, is an admirable work, being not only a very full account of the geology of the remarkable coal-regions of Nova Scotia, New Brunswick, and Cape Breton, but a complete treatise on the vegetable and animal fossils of the Carboniferous period, for the study of which these regions afford unusual advantages. From the treasury of facts contained in this large volume, as well as for some recent accounts written by J. P. Lesley, Pierce S. Hamilton, and a report of Walter R. Johnson, some years ago, and other sources, the following account is condensed. The coal is of the Carboniferous age; it lies directly northeast of, and is probably an extension of, that of Pennsylvania. The coal it produces is all of the soft or bituminous kind. The general title of Nova Scotia is here given as that by which the regions are commonly designated in the United States. These coal-regions are divided by older rocks into nine portions, but, for our present purposes, those of Pictou and Cape Breton are much the most important, being the great coal-producing regions. Taken in their geographical order, however, beginning at the west and passing eastward, they are named as follows: 1. New Brunswick; 2. Cumberland; 3. Minas Basin; 4. Pictou; 5. Antigonish County; 6. Guys-

borough County; 7. Richmond County; 8. Inverness and Victoria County; 9. Cape Breton County.

Reserving the important regions of Pictou and Sydney, or Cape Breton, for after-consideration, we will first hastily dispose of the others, which are so much less productive. By referring to the map, p. 582, the reader can follow the descriptions:

1. *The New Brunswick* region is the most extensive in area, covering more than two-thirds of the entire extent of that province, occupying a triangular tract next to the peninsula of Nova Scotia, and the southern angle of the coal-field extending some distance south of the St. John's River, nearly to the line of the State of Maine. At Grand Lake, in Queen's County, in the southern central part of the field, the seams of coal are 22 inches in thickness, and, with this single exception, no bed sufficiently large or pure to be profitably worked has yet been discovered, nor can the prospects of future discoveries, says Dawson, be regarded as very encouraging. The whole formation is nearly horizontal, and, though of great superficial extent, has apparently but slight thickness. W. R. Johnson reports the covering as very light, not exceeding 10 or 15 feet in thickness. The quantity of coal raised at Grand Lake, in 1864, was 5,000 chaldrons, and is the ordinary bituminous or caking coal, but requiring frequent stirring for complete combustion. New Brunswick is a flat, carboniferous sandstone plain, and from the horizontal character of the formation, and its undisturbed condition, such beds as do exist may have a wide lateral extension; but, unfortunately, there is but one seam, and out of some twenty outcrops in different localities, where the coal is over five inches in thickness, but one measures two feet, and that is questionable.[1]

This whole New Brunswick coal-region, therefore, which makes so great a show on the geological maps, must be allowed to pass as of no importance whatever in the coal-market so long as the Pictou and Cape Breton regions, not far off, afford coal in such abundance, and in beds of large size.

New Brunswick, however, possesses a mine of a new and beautiful substance analogous to coal, called Albertite, which is deserving of notice at least as one of the curiosities of our subject. It is situated at Hillsborough, on Peticodiac River, in Al-

[1] Total production of coal during the three years 1869 to 1871, 22,050 tons.

bert County, near the head of the Bay of Fundy. Albertite is used in the manufacture of oil and gas, yielding 100 gallons of crude oil per ton, or 14,500 cubic feet of gas of superior illuminating power. It was discovered in 1849, and there were 19,267 tons of Albertite produced during the three years 1869, 1870, and 1871.

Unlike coal, it is found in a true vein, or filling a crevice in the rocks, and most authorities now agree in considering the substance as a variety of asphalt, or a solid hydro-carbon, originally fluid like petroleum, and derived from the decomposition of vegetable or animal products. Formerly, it was regarded by different authors as a true coal, an asphaltic coal, and a jet. It is a new material, intermediate between the most bituminous coals and the asphalts, and is found in the lower carboniferous formations. It has a beautiful and singular appearance, having a resplendent resinous lustre, a perfect conchoidal fracture, and it is perfectly free from mineral charcoal, and lines of impure coal or earthy matter. It is, however, divided into prismatic pieces by a great number of smooth, divisional planes proceeding from wall to wall.

Albertite coal (or solidified petroleum, as it is sometimes improperly called) is also found in Ritchie County, in West Virginia, where it is called Grahamite or Ritchie mineral. A brief notice of it will be found on page 288.

2. *The Cumberland* coal-region is the triangular county which connects the peninsula of Nova Scotia with New Brunswick, and is remarkable for the great number and small thickness of its coal-seams. The principal deposit now worked is the Joggins main seam, consisting of two beds, three feet six inches and one foot six inches, with a clay parting between, varying from one foot to a few inches. In 1868 there were only 9,240 tons mined, which were exported principally to St. John, New Brunswick. But, unimportant as is this region as to its coal production, it is one of the most interesting in the world as a geological study. While many other regions, producing very large quantities of coal for many years, are almost unknown, the South Joggins, with its multitude of petty seams of coal, has been immortalized in geological works by the genius of Logan, Lyell, Dawson, and others. This celebrated locality

is situated on the east side of the Bay of Fundy, where the tide rises 60 feet or more, and in the narrower parts runs at the rate of six or seven miles per hour. The clean-washed cliffs present the extraordinary spectacle of 81 separate seams of coal, from half an inch thick and upward, the largest in its most favorable exposure being above described. More than 30 of them are only one inch, and many others only three inches in thickness, and none of them of any economical importance, very few of them being more than six or eight inches thick. The frequent elevation and subsidence of the region during the coal-forming age, while it caused this minute subdivision of the coal-seams, was highly favorable to the preservation of the fossils peculiar to the coal-formations, and the conformation of the coast is favorable to its examination and measurement.

The whole thickness of the carboniferous rocks is reported by the distinguished geologist above named, Sir W. E. Logan, at 14,570 feet 11 inches, of which he made an elaborate section, to which subsequent examinations of Mr. Dawson add about another 1,000 feet, making a most extraordinary thickness. Prof. J. P. Lesley, who has also repeatedly visited the region, strongly controverts this: "That in one little spot of the earth's surface, like Nova Scotia, and that too midway between the coal-areas of America and those of Europe, wherein the thickness of coal-measures proper ranges from 2,000 to 5,000 feet, if they ever attain the latter size, there should be such an anomalous deposit," he says "is remarkable." He seems to think that much of the lower portion of what Mr. Dawson calls the coal-measures, but which contains no coals, belongs to the older Devonian rocks of the Chemung and Catskill age; while Mr. Dawson relies on the evidence of their fossils as proving them to be Carboniferous. But, as Mr. Lesley says in another place: "Men of science have such a different way of looking at and talking about facts from business-men, that the latter cannot take any interest in discussions of nomenclature and geological quantities. It is of no consequence to a coal operator whether one geologist calls the coal-measures 1,000 feet thick, or another geologist calls them 10,000 feet thick; provided they do not agree to increase or diminish the number and thickness of his workable coal-beds, he will let them fight at their leisure about

how many barren rock-measures they shall color red or blue on their maps, and call Carboniferous or Devonian in their lists of fossils."

3. Minas Basin is the northeast arm of the Bay of Fundy. On its south shore is the South Colchester and Hants district. Thin seams of coal have been discovered at several points near the margin of the basin, but no mines have been opened, and its value as a productive coal-field yet remains to be proved. In the North Colchester field, on the north side of the same basin, coal has been mined to a small extent; but, although several seams have been discovered, they are so thin, that to work them in the present state of the coal and labor market would not prove remunerative. Dr. Dawson says none of them exceed 18 inches in thickness.

5. Antigonish County is immediately east of Pictou, on St. George's Bay; until recently, it was supposed to belong to the Barren Lower Carboniferous, but explorations were being prospected in 1868, with the sanguine hope of discovering seams of coal that can be worked with profit.

6. Guysborough County, south of the last, has a band of carboniferous rocks, but Dr. Dawson says he has not seen in it any coal.

7. Richmond County, in the southern part of the island of Cape Breton, presents the remarkable peculiarity that the coal-seams have been folded up by lateral pressure. A bed of coal four feet thick is said to have been found. The chief Commissioner of Mines reports, for 1868, only 33 tons of coal mined in Richmond.

8. Inverness and Victoria Counties are the north end of the island of Cape Breton. The carboniferous rocks are reduced to narrow belts, and contain two seams of coal four and six feet thick. A mine is opened in each; in the former, at Chimney Corner, 200 tons were produced in 1868, and in the latter, at New Campbellton, 1,490 tons are reported for the same year.

The foregoing is a fair summary of the coal-regions of New Brunswick, Nova Scotia, and Cape Breton, except the two regions of Pictou and Sydney, which it will at once be seen are so much better that, for all useful, practical purposes, we might have omitted all the others.

4. The Pictou coal-region is on the north shore of the peninsula of Nova Scotia, and near the centre of the great semicircle formed by the coasts of New Brunswick, Nova Scotia, and Cape Breton. It presents the striking contrast to the others that, while they have thin seams of coal, and sometimes great numbers of them, we have at Pictou very large seams or masses of coal, as curious, from their thickness, as those of the Joggins are from their great number and small size. The accounts vary as to the actual size of these beds. Mr. Lesley, in the article hereafter given, speaks of them as 60 or 80 feet, but he probably includes some of the black shale and clay. W. R. Johnson speaks of the great seam at Pictou as 12 feet thick—referring, probably, to the portion that was worked. Dr. Dawson's section makes the main coal-seam 39 feet 11 inches; the deep coal-seam, 157 feet below the above, 24 feet nine inches thick; and the McGregor seam, which is 280 feet deeper, 11 feet thick. This section he makes from a comparison of the borings and excavations by different companies in order to give a general idea of the structure of this coal-field. They are given as a mere approximation, and, strange to say, the beds being inclined at an angle of 20°, the measurements are taken in a line perpendicular to the surface.

"Acadian Geology" gives a multitude of details in regard to this section, with elaborate analyses of each layer or foot of coal, the large seams described being separated into many smaller seams by layers of slate, iron-stone, and pyrites.

Generally, only 12 feet in thickness of the upper part of the seam is worked, the lower portion being considered inferior in quality; though, in recent years, the lower part of this seam, and also the deep seam, have been worked. Dr. Dawson says: "The worst defect of Pictou coal is, that it contains a considerable quantity of light, bulky ashes, and this causes it to be much less esteemed for domestic use than on other grounds it deserves." His analysis of the upper 12 feet gives an average of 13.3 per cent. of ashes; that of the lower part averages 14.2 per cent. of ashes. In regard to the important question as to the extent of these large beds of coal, it should be understood that apparently the body, or by far the more extensive parts of this Carboniferous region, is now under the waters of the

Atlantic and the Gulf of St. Lawrence. An unpropitious power has left us only the very extremities, at Pictou and Sydney, on the shores of the ocean, of the vast coal-fields which are supposed to have been destroyed or submerged.

In 1849, Prof. Johnson reported that Mr. Brown estimated the area of the Pictou field at 28 square miles, but that, owing to numerous faults and dislocations, the available space for mining is much less than that, and that the only seam then worked was, by Mr. Brown's estimate, known to underlie not more than three square miles.

Mr. Lesley, in 1869, said, "It is local in the strictest sense, and cannot be discovered four miles from the shafts." Mr. Pierce S. Hamilton, in 1868, reported that it might be roughly estimated, including what was believed to be an eastern extension of it, to Merigomish Harbor, at 30 square miles, upon which there were eight collieries then in operation. It is a significant fact that the company which formerly owned all the coal in Nova Scotia, in selling out the property to the Government, reserved in this important locality only four square miles.

Dr. Dawson does not give any precise statement as to the area of the large Pictou beds of coal, but occupies much space in describing the complex character of the formation which seems to present so many faults, synclinal folds, and other of the puzzles of the geologist, as leave its extent a question to be solved by the slow and expensive process of mining and exploring in a very disturbed coal-region.

As to the explanation of the wonderful geological phenomenon of these very thick bodies of coal in the midst of a region where, in other localities, there are scores of very small seams, Dr. Dawson's theory is, that a "ridge of older rocks must have been surrounded with a deposit of gravel in the Millstone-grit period, and so often as the region was submerged, this ridge, with its associated gravel, must have formed a dam or barrier which protected the enclosed area, and thus accounts for the very exceptional character of the enormous coal-beds included within it."

9. The Cape Breton County region is the last, the most extensive, and most important of the Nova Scotia coal-regions. It is situated on the most eastern part of that island. The coal-

beds are undulating along a series of anticlinal and synclinal lines, and the coal-rocks are simply the ends of three troughs, like the prows of three great vessels that had been run ashore, and of which all else had been broken off and washed away, or sunk deep in the ocean, toward the coast of Newfoundland. The most eastern and narrowest is that of Cow Bay; the second is Glace Bay, and the third is Sydney, which is a still broader trough. Prof. Lesley has published (Proceedings of American Academy, Philadelphia, 1862) a detailed section of the measures at Glace Bay, 907 feet thick, showing one seam of four and one of five feet, with a number of small seams. Of the so-called lower measures, at a later period, he says they contain but one workable bed, scarcely four feet thick, in from 4,000 to 5,000 feet of coal-measures. There are dozens of other beds, but they are all of a thickness of from one inch up to 12 and 15 inches, only one of them reaching the size of three feet. The quality of the coal, and the capabilities and prospects of the whole region, are sufficiently described by Mr. Lesley in the account given below.

This region exceeds all the others in its export of coal, producing two-thirds of the whole quantity raised in Nova Scotia. It is, therefore, the most important mining district in the Dominion of Canada.

Mr. Brown estimates that the productive coal-measures cover an area of 250 square miles, but Mr. Lesley's account seems to indicate a less superficial area of good coal.

Johnson, on the authority of Mr. Brown, reported only 120 square miles of land containing workable veins of coal. It extends about 35 miles along the coast, and four or five miles in width, but this includes numerous bays and indentations of the coast.

As there is a very erroneous opinion prevalent among business-men in the United States, in regard to the extent of the Nova Scotia coal-fields, and their ability to compete with those of the United States for the trade of the seaport cities, the foregoing details of each region are given, and the following account of them by that eminent and practical geologist, J. P. Lesley, is also reproduced:

"The fields of Nova Scotia, so far from being 'inexhausti-

ble' in the popular sense of that term, are small in extent, worked with difficulty, and got away at great expense and under severe commercial conditions. We speak from personal knowledge, having spent two successive seasons in an instrumental reconnoissance of the best portions, those situated on Great and Little Glace, Cow, and Miré Bays. The coal-beds are here of handsome size and highest quality, fully equal, in all respects, to our own Westmoreland gas coal-beds in portability, purity, and richness of material, and in thickness and uniformity of deposit. But the coal-beds of the field lying north of Sydney Harbor are not only limited in area, but thinner, and meaner in quality, and reached only by shafts of considerable depth. These are the old Duke of York's mines. The Pictou field is quite as small as the old Sydney field, is more awkward to mine, and yields a miserably poor quality of fuel. Although two of its mines exhibit an astonishing thickness of coal (60 or 80 feet through the so-called big bed), yet this mass is local in the strictest sense, cannot be discovered four miles from the shafts, and is made up of a multitude of layers of poor coal, slate, and sulphurous clay ironstone, alternating with one another. Nothing but the exacting demand of an old settled seashore, inhabited chiefly by fishermen, and studded with villages, and the impossibility of getting coal from anywhere else, would have ever kept the exploitation of the Pictou field alive.

"These are the only three 'fields' which Nova Scotia really has. Coal, turned up sharply on edge and scarcely rising above the level of the sea, shows itself on the edges of Cape Breton, both north and south, and a few miles back from the Gut of Canso. But it immediately plunges into the water, and spreads itself underneath the red sandstone deposits of the Gulf of St. Lawrence. Nothing will ever be done with these fragmentary outcrops—nor with the world of coal buried forever beneath the gulf.

"Even the Glace Bay region consists of the tip-ends of a group of shallow parallel basins which (all except these tip-ends) lie side by side buried under the Gulf of St. Lawrence, presenting their eastern extremities in like manner upon the western coast of Newfoundland. The broadest of these basins comes on shore at the old Red Head, where are the remains of

a French fort, evacuated when the New-England colonists captured Louisburg. Here the top bed, 10 or 11 feet thick, spreads back from the shore in a semicircle only about a mile; that is all there is of it. The six-foot bed (of excellent coal) sweeps its outcrop round the first in a larger semicircle, from the harbor-mouth to the shore beyond the Red Head. The next is the eight-foot bed, with a still larger area; and underneath it are two or three of smaller size, making wider and wider sweeps. But the lowest of these beds do not reach half-way to Sydney, which is only 20 miles distant. They all lie nearly flat, that is, on slopes of from 1° to 5°. And the entire contents of all the beds in this the largest of the basins, not deducting any thing for mining, is only say 300,000,000 tons. When one considers the scarcity of capital, the sparseness of population, the distance from all the manufacturing centres, the consequent continual mechanical embarrassments of the mines, the ice-block of the winter months, the perpetual fog-bank which makes the navigation of the Atlantic coast and mouth of the gulf so dangerous, and the necessity for taking off the coal, when mined, in lighters to vessels riding at anchor, except at the recently-constructed harbor of Little Glace Bay, and the harbor in progress of construction at Great Glace Bay—it would be ridiculous to anticipate the possibility of an effcient competition of these mines with ours.

"The only coal interests in the United States, which might fear the introduction of the Nova Scotia coals, supposing them to come into our ports in any quantity, are the small local fields of Cumberland, Broad Top, and Westmoreland; and these can always, under any circumstances, undersell the Nova Scotia coals in every market of the coast, except the seaports of New England. Besides all which, stands the fact that Halifax, St. John's, in Newfoundland, Quebec, and Montreal, Prince Edward's Island, Gaspé, and a hundred hamlets along the shores of the peninsula, the islands, and the Gulf of St. Lawrence, all the way up, draw their supplies of fuel from these poor little fields which, all combined, would not make up much more than the end of the Pottsville Basin from Tamaqua to the Mauch Chunk Summit mine, if as much.

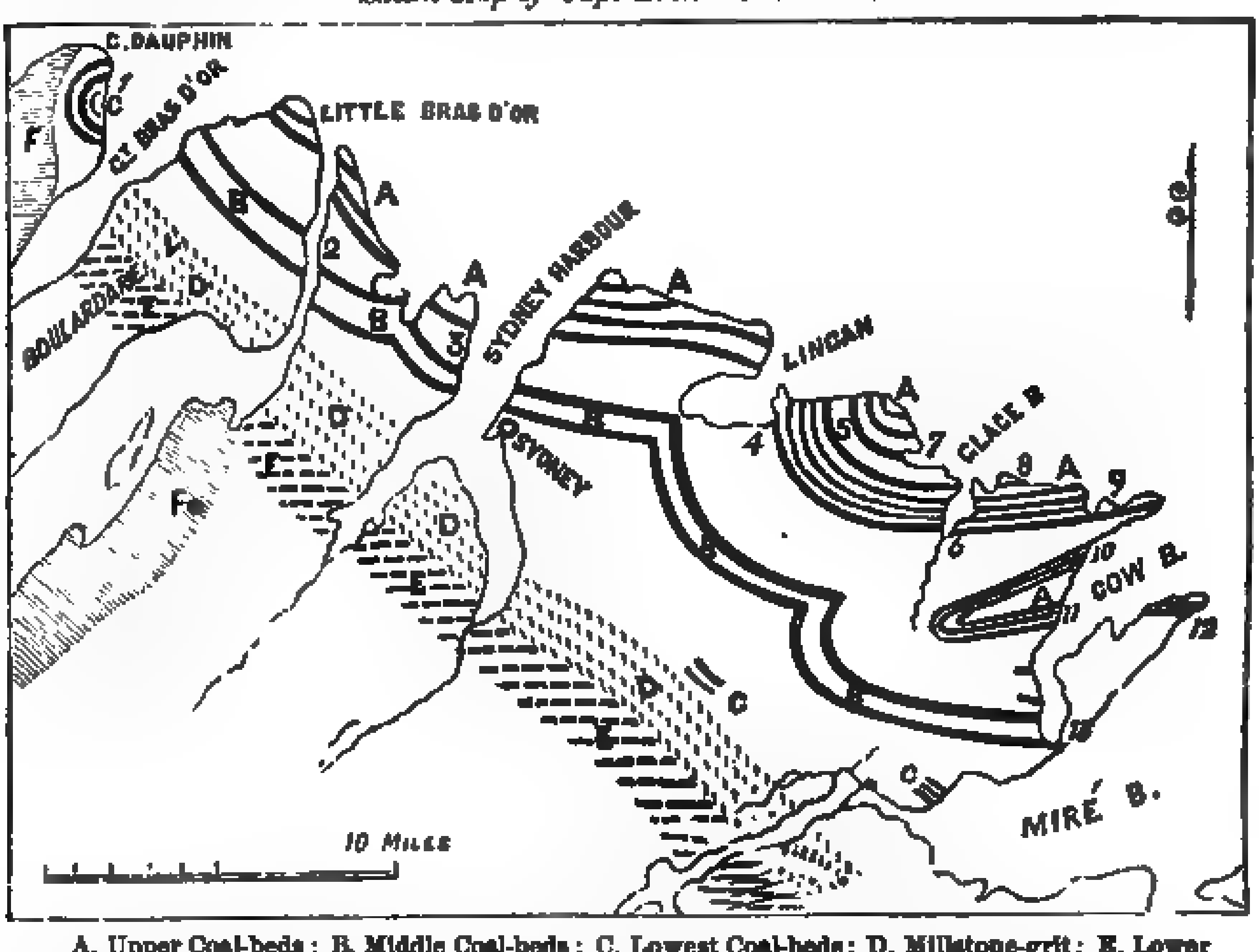
"It is very true that the superb gas-coals of the Glace Bay

DR. DAWSON'S MAPS OF PICTOU AND SYDNEY COAL-FIELDS.

Sketch-Map of Pictou Coal District.

A, Upper Coal formation; B, Middle Coal formation; C, New Glasgow conglomerate; D, Lower Carboniferous; E, Devonian and Silurian. *Coal Areas.*—1. General Mining Association, or Albion Mines, 2 and 4. Acadia; 3. Nova Scotia or French's; 5. Intercolonial or Bear Creek; 6. Montreal and Picton or Haliburton's; 7. German Company, and others; 8. Sutherland's River; 9. New Glasgow, or Kirby's.

Sketch-Map of Cape Breton Coal-Field.



A, Upper Coal-beds; B, Middle Coal-beds; C, Lowest Coal-beds; D, Millstone-grit; E, Lower Carboniferous; F, Metamorphic Silurian. *Mines.*—1. New Campbellton; 2. Little Bras d'Or; 3. Sydney; 4. Lingan; 5. International; 6. Caledonia; 7. Little Glace Bay; 8. Clyde; 9. Schoner Point; 10. Block-House; 11. Gowrie; 12. South Head; 13. Mire.

Note.—It should be observed that there are probably several beds of coal between series A and series B, and that the lines of outcrop of series B, C, D, and E, are not known in detail.

beds supply the gas-works of Boston, Cambridge, and other towns of New England, and are mixed with our Western Pennsylvania gas-coals at the gas-works in New York. But this has been the case for several years, since 1862 or 1863, and is entirely irrespective of the tariff. For gas-making quality is every thing; a dollar or two more or less does not exclude. But when quantity is required—that is quite different.

"Whether for good or ill—we offer no opinion on that head—whether for good or ill, coal-miners may set their hearts at rest about Nova Scotia coal. It is not of a quality good enough (in the gross)—it cannot be mined in quantities large enough (at the best)—to affect the American market."

Dr. Dawson gives analyses of Pictou and North Sydney coal, showing that the former yields a large amount of ashes, and in the latter the presence of a little bisulphuret of iron:

"There could not be a more damaging sentence for both these coals, the one being full of ash, and the other of iron and sulphur; the one choking and the other clinkering; neither of them fit to approach iron; and with too low a percentage of volatile matter to make gas. We say this with no invidious feeling. We have plenty of such coal in our own fields in Pennsylvania. The Richmond coal is worse. The Mississippi coals are still worse. But it is proper to place all things in an equal light, that everybody may avoid misapprehensions, illusions, exaggerations; for these are the obstacles to a just life, in trade as in morals. And we have already given a more favorable account of the sub-district south of Sydney Harbor, which is traversed by outcrops of good gas and iron-making coal-beds—as good as any in Western Pennsylvania. But we repeat, their run is short, their mining-room limited, their exportation expensive, their owners resolved to make a good deal of money on a moderate plant of capital—all which is a benefit to certain individuals, but a bar to competition for the markets of the United States. It must be kept in mind that these mines have been wrought for half a century, under the able management of an agent, Mr. Brown, of Sydney, who has grown old and rich upon the ground; and nothing but the leanness of the measures and their narrow geographical extent could have prevented the growth of an immense trade, which

our coal-operators, whose mines are not so old, would have felt long ago. And if it be objected that the Duke of York monopoly was deficient in energy, and that it was to the agent's personal interest not to expand the operations, the reply is easy, that the monopoly was destroyed by the Colonial Legislature ten years ago, and the lands of the coal-district south of Sydney Harbor (Lingan, Glace Bay, Cow Bay, Miré Bay) were thrown open to all comers, under a mining act of the most enlightened and liberal kind.

"Some of the shrewdest and soundest capitalists of Boston and New York have purchased them, and are doing their best to operate them, under about a dozen organizations. Large sums have been spent in deepening harbors, building sea walls and piers, sinking shafts and slopes, and laying tracks; but all this has to be done in an unsettled country, at a vast distance from the machine-shops of the world, with a population of fishermen speaking the Gaelic language, and on the shores of a gulf against which the arctic ice, floating down through the Straits of Belle Isle, banks itself sometimes to a distance of 40 miles out, so that seal,-bear, and foxes, have been hunted on it; while across the mouth of the gulf hangs for a great part of the year a perpetual fog-bank, 50 miles wide and a mile high, making navigation dangerous.

"But, were all obstructions to mining and exporting these coals entirely removed, it would be just as unfortunately true that the export must be small, owing to the fewness and thinness of the beds, and to their peculiar situation—a situation which makes a small trade very easy (for the mines are close to the sea, and the beds actually crop out in the cliffs beaten by the waves), but a large trade impossible. One or two of the companies now mining will make money, and from a plant of a few hundred thousand dollars will get large dividends. But all the rest will barely keep their trade alive, without the possibility of increasing the total exports of the district.

"If our statement above be received, it will follow that to take off the tariff from coal, for the sake of allowing the Nova Scotia coals to enter our sea-ports in sufficient quantity to lower the price of the raw material for the benefit of American manufactures, would have no other effect than to deprive the United

States Treasury of that many thousands of dollars, leaving the coal-market precisely in its present condition of fluctuating high prices, from which some other method of relief must be devised by those who feel themselves aggrieved.

"The Nova Scotia fields are too small and undeveloped to furnish much more than the neighboring coasts require; and, besides that, contain, with some exceptions, only beds of an inferior quality; and the exceptional beds yield only coal of a particular quality, unsuitable for our use, except in the one manufacture of gas, and for ocean navigation."

The three worst things that could be said of the coal of any region are, that it is of poor quality, that there is but little of it, and that it is inaccessible.

Nova Scotia Coal-Trade.

The following table, from the reports of the Chief Commissioner of Mines, gives the annual amounts of coal mined and shipped in Nova Scotia from 1827 to 1873, inclusive:

Years.	Tons.	Years.	Tons.	Years.	Tons.
1827	11,491	1843	97,200	1859	267,496
1828	19,429	1844	99,993	1860	304,129
1829	20,252	1845	137,908	1861	334,565
1830	25,240	1846	134,393	1862	393,631
1831	34,424	1847	183,099	1863	424,425
1832	46,585	1848	170,508	1864	576,934
1833	59,497	1849	158,954	1865	635,586
1834	46,679	1850	163,728	1866	558,519
1835	57,818	1851	131,976	1867	471,185
1836	98,427	1852	171,821	1868	453,624
1837	109,347	1853	196,935	1869	511,794
1838	97,938	1854	213,250	1870	625,769
1839	133,928	1855	216,338	1871	673,242
1840	98,267	1856	231,934	1872	880,950
1841	136,110	1857	268,808	1873	1,051,467
1842	119,478	1858	289,618		
Total production in 47 years					12,145,682

Average per annum, 258,418 tons.
Average of last five years, 748,644 tons.
Exported in 1873, 327,834 tons.

Nova Scotia coal was free of United States duty from 1854 to 1865, and the average annual production of those twelve years was only 333,427 tons.

A monopoly of these coal-regions was granted to the Duke of York in 1826, but it was relinquished in August, 1857.

The coal, in 1873, was produced from the following mines:

COAL PRODUCTION OF NOVA SCOTIA DURING THE YEAR 1873.[1]

COLLIERIES.	Seams.	Produce. Tons.
Cumberland County.		
Joggins	Joggins Main	19,325
Scotia		1,562
Spring Hill	Black	6,704
Pictou County.		
Acadia	Acadia	112,808
Albion Mines	Deep	48,890
	Main	97,024
Intercolonial	Acadia	41,821
Mitchell & Co	McBean	418
Nova Scotia	Acadia	85,908
Vale	McBean	8,080
Cape Breton.		
Block-House	Block-House	52,571
Caledonia	Phelan	75,202
Lorway	Emery	28,540
Gardirner	Lorway	9,169
Glace Bay	Hub	46,817
	Harbor	21,888
Gowrie	McAulay	59,625
International	Harbor	75,380
Lingan "Land"	Lingan	85,094
Lingan "Sea"	Lingan	1,626
Lingan	Barrasois	829
Ontario	Phelan	8,894
Reserve	Phelan	68,929
Schooner Pond	Emery	18,901
Sydney Mines	Sydney Main	127,398
	Lloyds	6,924
Victoria	Ross	12,809
Inverness County.		
Chimney Corner		884
Victoria County.		
New Campbellton		457
Total tons		1,051,467

SALES OF THE COAL PRODUCED IN 1873.

In the Provinces.	Tons.	Exported to.	Tons.
Quebec	187,059	United States	264,760
New Brunswick	68,217	West Indies	54,213
Newfoundland	55,861	Great Britain	6,976
Prince Edward Island	26,840	South America	1,885
Nova Scotia—Land sales	60,962		
" Sea borne	154,838	Total exportations	327,834
Colliery consumption	110,841	Domestic sales	663,613
		Stock on hand	60,020
Total domestic sales	663,613		
		Total product	1,051,467

During the first six months of the year 1874 there were 500,600 tons of coal raised from the Nova Scotia and Cape Breton coal-mines.

NOTE.—Dr. Dawson wholly dissents from Mr. Lesley's statements on the coal-fields of Nova Scotia, copied in this chapter, both as to his facts and inferences.

[1] *See* Supplement on page 686.

APPENDIX.

I.

ORIGIN OF COAL, AND THE METHOD OF ITS FORMATION.

Coal is not a mechanical mixture or formation, nor is it a chemical compound. Unlike limestone, gypsum, granite, sandstone, or other rocks, and unlike all the other productions of the earth except peat and lignite, which are of the same class, coal is the production of vegetable matter which grew upon the place where it is now found; and the process by which it was converted from woody matter into coal is mainly accounted for by two causes, moisture and pressure.

There seems to be no reasonable doubt that coal is the production of vegetation, and that too of a very wonderful vegetation. Cold and dull, indeed, must be the intellect which has no curiosity to see or to learn something of the gigantic trees and plants of the ancient world, and of which the fossils are found among coal. Before the discovery of America, it is said there were sometimes found on the coast of Europe strange-looking trees and reeds of immense size, which had been drifted ashore by westerly winds. With what interest must those waifs from an unknown land have been viewed by the philosophers of that period! If, when some deserted ancient city, like those of Central America, was discovered, objects of Nature and art were found of a vastly greater size than those of our day, what interest they would excite, not only from their dimensions, but from their antiquity! With some such feelings, you can see, in any coal-mine, wonders of Nature more remarkable than those supposed, and of much greater antiquity. Here are found layers of slate and sandstone rock, both above and below the coal, often separating it into two or more seams in which you will discover the impressions of the leaves and stems of land-plants, and of the trunks of large trees, of kinds not now found on the earth; made upon the rocks when they were soft clay, sand, or mud, and these impressions are in a very perfect and plain form, being complete copies of the plants in all their minute details, sometimes showing even the small veins on the leaves. As you pass along one of

these underground galleries, you can see in the roof or rocks overhead an extraordinary collection of vast quantities of the prostrated and flattened trunks of trees of great size and length, and unknown species; presenting so little variation in their thickness for long distances as to give us an idea of their wonderful size and height, when standing erect, for plants of that class or description. They are not sea-weeds, but plants that grew in the air. It must be regarded, too, as a very singular circumstance, that each seam of coal appears to have originated from a distinct vegetation, and miners and geologists find important indications for the identification of the several beds of coal in the preponderance of the impressions or fossils of certain plants peculiar to the seam, and found in the black slates immediately over the coal. So, in our day, a new species of forest-trees always grows up where a former growth had been cut down, the supply of germs of the old species being exhausted. This coal vegetation was of a description, compared with which, any thing in our day, of the same class of vegetation, in respect to its size and quantity, fades into insignificance.

The exuberant growth of vegetation in our tropical climates is astonishing to us, yet that is but as the grass of the field as compared with that of the coal era. For example, *equiseta*, or horse-tail flags, with us are never more than half an inch in diameter, while in the coal-rocks gigantic reeds of this kind are found as much as 14 inches in diameter. Living club-mosses, even in our tropics, attain no great height, while in the coal formation they are as thick as a man's body, and 60 or 70 feet high. Then there are any quantity of *Sigillaria*, those beautiful fossils, the impressions on the bark of which remind us of the work of the sculptor, containing on their surface impressions as distinct, regular, and beautiful, as if made by a seal upon wax by the hand of man, and hence their name.[1] There is a well-known plant found in our woods called the fern, which is of an insignificant size. A large part of the vegetation of the coal era is composed of ferns of incredible size, sometimes measuring 60 feet or upward in height. Therefore, as to the composition of the coal-slates, you must disbelieve the evidence of your own eyes, to deny the presence of vegetable matter, where they had their origin, for you see in them the daguerrotyped likeness of plants, leaves, roots, trunks, and branches. But, as to the coal itself, the evidence to the naked eye, of its vegetable nature, is not apparent, as it does not show impressions of plants like the slate-rocks.

The theory that coal was formed by the drifting of large masses of timber into bays, after the manner of the Red River rafts, now finds no advocates. The material could not have been furnished in sufficient quantity, and disposed in layers of equal thickness, extending for many miles, and so free from mud, sand, or other impurities or foreign substances. Coal of the Carboniferous age, when examined, is apparently never found to be formed of the trunks and large branches of trees. The slate-rocks described above were so formed, and it is on account of the size of the

[1] *See* cuts on pp. 183 and 185.

trees and plants that they have been converted into slate or shale instead of coal, from the introduction among them of sand, clay, and mud. The too great preponderance of earthy matter renders them unfit for fuel, although containing some portion of carbon.

The opinion now held by geologists is, that the vegetation from which coal of the Carboniferous age originated was similar to that of the peat-bogs now found in nearly all parts of the world. The examination of coal does not afford evidence of its having been produced from the flattened trunks or more solid parts of trees, but it abounds in fragments of the leaves, and occasionally extremities of branches and fronds, or leaves of the kind which retain the stalk when they fall off. In anthracite coal the process of liquefaction and carbonization, or perhaps it should be called crystallization, has obliterated nearly all traces of the original vegetable matter; but, as we go farther westward, we find some kinds of bituminous coal which appear to be composed of minute leaves and fibres matted together. Large trunks or branches are not found, but thin layers resembling mineralized charcoal are found between the layers of coal when separated, and the material appears to have been of that soft description which must have flourished either in water or when the land was little elevated above the water, and when the climate was moist and warm. Certainly the vegetable matter must have been immediately covered with water as soon as it was formed, in order to be preserved from the rapid decomposition which always takes place in the open air. Sea-weeds and other marine plants are not found in coal, but the plants are all of the fresh-water species, and it has been confidently asserted by Mr. Lesquereux that there is no coal with marks of marine origin; and, further, that there is no true peat formed entirely of sea-weed and marine plants, although the sandstone and limestone layers between the seams of coal often contain marine fossils.

"The supposition that coal is a true mineral, formed only by chemical agency, and without an accumulation of vegetation grown on the surface, and buried afterward, is an hypothesis to which Nature does not give the slightest support. The analogy of formation between the peat-bogs of our times and the beds of coal of the coal-measures cannot be called a theory, it is a demonstrable fact. We can now see the coal growing up by the heaping of woody matter in the bogs. After a while we see it transformed into a dark, combustible compound that we name peat or lignite, according to its age. We then see it hardening, either by compression or by this slow burning in water. The oldest peat-bogs in Europe have at or near their bottom some plates or thin layers of hard, black matter that ocular examination or chemical analysis fails to distinguish from true coal. We find, besides, in Holland, Denmark, and Sweden, thick deposits of peat separated into distinct beds, by strata of mud and sand, giving the best possible elucidation of the process of stratification of the coal-measures."

In Switzerland peat grows at the rate of two inches per year, a thickness reduced to one-half by compression. The trunks of trees embedded

in peat are generally first softened before being hardened, as Liebig has proved by direct experiment in the process of slow decomposition, or rather slow combustion, of woody matter in water. Hence the flattening of all the stems found in coal or in the shales.—Lesquereux.)

There are many proofs that the material from which coal was formed had previously been in a soft or even a fluid state. At the Barclay (Pennsylvania) mines, fossilized round limbs of trees are often found in the coal four or five inches in diameter, converted into slate or sandstone, with the knobs on the woody surface well preserved, but without the bark, and lying in the coal-bed; but always next the roof, immediately on the top of the seam. If these occur in the top slates, they are crushed and completely flattened, but, when pressed into and embedded in the soft, mud-like, ancient peat, their rotundity has been preserved. Here, as in all other instances, the woody matter found in coal is never converted into coal, although sometimes it appears as if the bark was so changed.

An instance was discovered by Prof. Hall in Iowa, of part of a coal-bed being forced, in a fluid state, by the superincumbent pressure downward, through a crevice in the rocks into a small cavern in the Devonian limestone below the coal-measures, and there converted into coal, with a leader of coal exposed in a quarry connecting it with the main bed above, from which the material was derived. The strange deposits of large masses of coal in irregular forms in Central Missouri, in rocks older than the Carboniferous, are recalled to mind in this connection. In our day peat-beds formed on a sloping surface, when deluged with rain, have slidden or flowed into the valleys below, covering them to an unusual depth.

But how was all this vegetable matter accumulated? The large oceans which existed in the Carboniferous age would produce a very moist atmosphere. Many persons are not aware how much we are indebted to the moisture in the atmosphere for the temperature now existing at the surface of the globe. The atmosphere receives a continuous supply of aqueous vapor from the surface of the ocean on which it rests. In the Carboniferous age there was much less land and more ocean than at present, and therefore the atmosphere had more moisture. This vapor is a perfectly impalpable gas, diffused even in the clearest day throughout the atmosphere, and is not to be confounded with clouds or visible mist, which are aqueous vapors more or less condensed. Its quantity is small compared with the oxygen and nitrogen in the air, but its influence is very potent, as its power of absorbing heat is thousands of times greater than that of the air. The heat which the earth receives from the sun would pass off, and an age of ice would return on our globe, but the aqueous vapor wraps it like a warm garment, and protects its surface from the deadly chill which it would otherwise sustain. Hence countries where the air is dry are liable to daily extremes of temperature. By day the sun's heat reaches the earth unimpeded, and renders the maximum high; by night, on the other hand, the earth's heat escapes unhindered into space, and renders the minimum low. Yet,

strange to say, aqueous vapor does not absorb the sun's rays and exclude them from the earth to any great extent, although it is so powerful in absorbing the rays of heat from the earth.—(Tyndall.)

The underlying fire-clay is the fossil soil on which the coal vegetation was produced, and it also formed the basin, impervious to water, which was necessary to the existence of the peat-bog, and this under-clay is filled with roots called *Stigmaria*, on which grew the *Sigillaria*.

In addition to the unusual moisture, and a few hundredths more of carbonic acid in the atmosphere, and sufficient warmth, as already described, there were evidently a very uniform temperature and an entire absence of frost, for the want of annular rings in the fossil plants proves that there was no winter, and there were no cold currents from arctic regions, for, as the same coal-plants grew at the same time in Europe and America, the same climate must have prevailed. When we add to all this the geologist's usual demand, "give it time enough," there would be no difficulty in accumulating material enough for the largest coal-seam in the world. The following excellent summary of the whole argument as to the origin of coal is by Prof. Lesquereux, whose writings, found in the State Geological Reports of Pennsylvania, Kentucky, Arkansas, Illinois, and in Dr. Hayden's Reports on the Territories, from which extracts have already been given, have exhausted the subject:

"The formation of the coal is now pretty well understood among geologists. It results from active growth of woody plants, whose *débris*, falling every year, are preserved against decomposition by stagnant water, or great atmospheric humidity. It is the process which now still forms our deposits of peat. It demands for its favorable action a ground or basin, rendered impermeable by a substratum of clay, a peculiar kind of plants, constantly growing at the same place, and heaping their *débris* for a length of time. At our epoch the formation of peat is essentially of two kinds. Either the vegetables which furnish the materials are aquatic, or semi-aërial plants, having their roots in water, and expanding their branches, leaves, etc., on the surface of the water, or above it. Their *débris* fall in water, and are heaped and preserved under it. In another way, and this is more generally the case, the plants of the peat-bogs are of a peculiar texture. Hygrometrical, like sponges, they absorb humidity by their aërial tissues as much as by their roots, and, thus protected themselves against decomposition from atmospheric action, they cover in their growth every kind of woody *débris*, even large trees, and afford to them the same protective influence. In that way the surface of peat-bogs of this kind grows constantly up. In that way also peat-bogs grow at our time upon the slopes of steep mountains, whenever atmospheric humidity is constant and abundant enough to furnish moisture for the life of those hygrometrical plants which now are mere mosses. The peat-bogs of the coal did grow in the same way; the distinction in cannel-coal, which has been formed under water, and bituminous coal, which, by its layers, indicates an upper aquatic growth, is well marked. But, during the Carbonif-

erous epoch, the circumstances favorable to the growth of the peat were in their highest development. Low, wide basins of stagnant water, whose bottom was first coated by deposits of clay; an atmosphere constantly charged with vapors, and a large proportion of carbonic acid, the food of plants, forming by its transformation the woody tissues; floating vegetables of immense size, first growing horizontally at the surface of the water, and filling the basin with their *débris*, then forming a support for a more aërial vegetation; fern-trees, lycopodes, horse-tails, all of enormous size, heaped in a continuous growth, the woody tissues of their vegetable remains in a now unconceivable proportion. Our thickest beds of peat now measure scarcely 20 feet. By compression and mineralization the thickness would be reduced to one-sixth, or three feet at the most. We have beds of coal of 20 feet of thickness which would make a deposit of peat reach 120 feet. It is true, indeed, that the peat-bogs of old did not extend over the whole surface; that they were of various dimensions, sèparàted by sandy hills or by deep lagoons; that, after the deposit of their materials, erosions caused by water or other agency have greatly diminished their size. But it is true also that beds of coal, like the Pittsburg bed, whose average thickness is about eight feet, may be traced over surfaces more than 100 square miles in width. It is equally true that beds of coal are superposed at intervals, in the coal-measures, in such a way that at the same place a boring of a few hundred feet may successively pass through five beds of coal, or even more, of various thicknesses. So immense, indeed, are the riches of the American coal-measures, that, in their conception of the future development of our human race, geographers, historians, philosophers, agree in this idea, that in the United States we have, especially in our coal-deposits, the elements for the greatest and most perfect development of the human race."

The pressure required to transform the vegetable material into coal was applied by the formation of the superincumbent strata of rock, by means of the sinking of portions of the land and the elevation of other portions. Prof. Rogers, of the Pennsylvania Geological Survey, seems to attribute these to those mighty movements of the earth's surface called earthquakes, but they are now commonly accounted for by more gradual movements. The present great elevations of the mountains had not taken place, the surface of the earth was not much above the ocean, and small changes of level were sufficient to submerge the continents which were sometimes above and sometimes below the water.

Dana teaches that contraction of the earth's crust, in cooling, was the one complete, efficient, and universal physical cause of the development of the features of the earth. Certainly, by whatever cause produced, our everyday observation proves that a considerable part of the continent of America was for a long period the bottom of the sea, and was subsequently elevated, as is shown by its abounding in sea-shells and other organic remains, and we find the stratified rocks fractured and raised up at various angles, just as they would have been if the crust of the earth had been

broken into fragments by some mighty force acting beneath it. The elevation of a part of the earth's surface, and depression of other portions, would cause the sea to roll in against and over the continent. Where slate and sandstone occur over the coal, it is caused by the forests upon the higher ground being uprooted and strewed over the bog or swamp, before described, and the clay, sand, and earthy matter, becoming mingled with these drifting trees, they were spread in a promiscuous mass over the swampy flat.

The great strata of sand-rock upon the slate, and sometimes directly upon the coal, were caused by more impetuous inundations of the ocean in all its might and majesty, washing away vast quantities of the soil and rocky strata of the ancient continent; breaking the rocks into small fragments, carrying them to a great distance inland, and wearing them into water-worn pebbles. These rivers or oceans of sand, gravel, and clay, thus deposited, in course of time became hardened into rocks, and their pressure upon the moist and rank vegetation of the coal-bogs buried beneath them has thus, by a simple and natural process, formed the strata of slate, pure coal, and sandstone. The dense, tough mass of swampy growth, with its strong net-work of roots, fibres, leaves, and twigs, from the greater abundance and density of the vegetation, remained in its natural unmixed condition, and, no intermingling of earthy materials taking place, pure coal was formed. Being very compactly matted together, it formed a strong spongy mass, not easily separated by a current of water flowing over it, and not pervious, or liable to be penetrated by foreign substances borne by such current.

The formation of different kinds of coal, such as anthracite and semi-anthracite, semi-bituminous, and the many different varieties of bituminous coal, is supposed to be owing to the different degrees of progress made in the process of liquefaction and carbonization, and to there having been greater means for the escape of the gaseous constituents in some cases than in others. Chemists have actually converted vegetable matter into coal of all degrees of hardness, and possessing all the various qualities of that formed by Nature.

The combinations formed by the usual affinities of the constituents of coal seem to show that all coal was first formed of the bituminous variety, and that anthracite is the result of igneous action to which it was subjected after it became coal. Anthracite is only found in metamorphic rocks, and all coal found in metamorphic rocks is anthracite.

"Coal, it may be easily demonstrated," says Dr. J. S. Newberry, "has been derived from the decomposition of vegetable tissue, and represents one of the different steps in a progressive change. In peat and lignite, we see the first step in the formation of coal. Peat is bituminous vegetation, generally mosses and other herbaceous plants, which, under favorable circumstances, accumulate in marshes called peat-bogs. Lignite is the production of a similar change effected in woody tissue, and, because it retains to a greater or less degree the form and structure of wood, has

received the name it bears. Peat is the product of the present period, and lignite is found in deposits of recent geological age. In the older formations, these carbonaceous accumulations are still further changed, and form bituminous coal. When special and local causes have operated to carry the change still further, as when the beds of coal have been involved in the upheaval of mountains, and heat acted upon it, it is converted into anthracite. When this metamorphosis has been carried still further, the result is plumbago or black-lead.

"The changes referred to consist in the evolution of a portion of the carbon, hydrogen, and oxygen, in the form of water, carburetted hydrogen, carbonic acid, etc., leaving constantly a larger portion of carbon of the plant behind, with all its earthy matter.

"We find that, under peculiar circumstances, Nature has departed from her usual routine, and has locally effected the changes from lignite into anthracite, in a short space of time, as at Santa Fé, New Mexico, where a trap-dike has cut through Cretaceous strata in which are beds of soft and nearly valueless lignite, and where, over a large area, this outflow of melted rock has converted this lignite into a compact and valuable anthracite. So at Los Bronces, in Sonora, Triassic coals are converted into anthracite by the eruption of porphyritic rocks. On Queen Charlotte's Island, south of Alaska, is a Tertiary lignite changed by a similar cause into the most beautiful and brilliant anthracite."

Cannel-coals have usually a more distinctly laminated structure, are finer and more compact in texture, and contain a larger percentage of volatile matter. They produce gas of greater illuminating power, but the coke made from them is of inferior quality. As to the mode of the formation of cannel-coal, Prof. J. S. Newberry proved many years ago, in *Silliman's Journal*, that its peculiarities are owing to the chemical and mechanical influence of water in which it is deposited. Cannel-coals are characterized by greater homogeneity than other bituminous coals, as to their physical structure and chemical composition having a more laminated fracture, in pure specimens conchoidal across the planes of stratification. They contain more earthy and more volatile matter, less carbon, and evolve gases having a higher illuminating power.

Cannel-coals are frequently found shading into bituminous shale, into which they are converted by accessions of earthy matter. Bituminous shale and cannel-coal may, therefore, be considered as the same substance in different degrees of purity, that is, carbonaceous paste deposited from aqueous suspension with different admixtures of earthy matter.

Plants, when deprived of their vegetable life and exposed to the action of the air, are decomposed by a process of decay which is really a slow combustion unattended by the sensible phenomena of light and heat. Under water, the process goes on more slowly; and the more perfectly the oxygen of the air is excluded, the larger the proportion of the volatile constituents of the wood will be retained. Thin layers of cannel, alternating with others of bituminous coal, are due to the variable quantity of

water overflowing, and saturating the marshes, the cannel layers being deposited during the prevalence of high water.

Repetition of the Seams of Coal.—In Illinois and other Western States there is probably not one of the principal seams of coal that has not, at some locality, a bed of limestone more or less pure associated with it, containing the fossilized remains of marine animals in such a perfect condition as to leave no doubt that they lived on the spot where they are found. These fossiliferous strata occur between the different beds of coal, so as to show that if the coal was formed in fresh-water marshes, as the character of its vegetable fossils proves, near the sea-level, as is generally supposed, there must have been a subsidence and elevation for every seam of coal, as the intervening marine beds attest the presence of the sea when they were formed, as is also proved by the fossils of sea-shells, corals, and teeth and spines of cartilaginous fishes.

The formation of other seams of coal above the first is therefore to be accounted for by the new-formed strata filling up the water to the surface, the growth upon it of a second crop of peat-bog material, a second submerging, and a repetition of the original process throughout.

The thickness of a seam of coal depends on the length of time the vegetable materials of which it was composed were accumulating. Seams of coal are also sometimes split, as it were, by a wedge-like field of slate, which has been caused by an inundation of carboniferous mud flowing over a part only of the peat-bog region in its half-finished state, the subsequent growth of the remainder of the formation on the mud, and the thickening of the part not thus inundated. In the Mahanoy anthracite coal-region is a great bed of coal called the Mammoth, but, when we go west to Mount Carmel, we are told that it is split in this manner into two separate coal-beds, and so is the Baltimore bed at Wilkesbarre divided between that place and Pittston. The fragmentary character of the coal-fields is evidently caused by convulsions which took place long subsequent to the formation of the whole of the coal-measures, and we now possess, or at least have only discovered some of the broken parts of a vastly greater field which once existed on this continent. Deep valleys have been formed, cutting down through the coal-regions, leaving sometimes only small patches of coal on the tops of the highest mountains, and extensive countries often lie between, where thousands of feet in thickness of the upper formations, including the coal, have been removed by some mighty agency exposing the Devonian and Silurian rocks on the surface. "In imagination we can restore those gigantic arches which once carried the same coal-beds high through the air from one mountain across to another many miles apart, and which are now destroyed and buried up, constituting new sand, gravel, and rock deposits in the Atlantic."—(Lesley.)

The direction from which these ocean-currents proceeded is sometimes very evident. There are certain rocks peculiar to the coal-regions called conglomerates, the largest of which is the base of the coal, and they are evidently formed of the fragments of older formations, the sand and peb-

bles of which they are made being water-worn, rounded, and cemented together by smaller pebbles and sand. The bottom of the stratum in any given place is always composed of larger pebbles than the upper portion, showing very plainly the manner in which it was formed by material carried in water, the heaviest portion sinking first. Furthermore, these conglomerate rocks are much thicker and the pebbles larger in the eastern or southeastern part of the Alleghany coal-region, than they are farther west, showing that the current was spending its force in that direction. In the Lehigh and Schuylkill regions the pebbles are larger than hens'-eggs, and the formation itself is as much as 1,400 feet thick. Farther north, at Towanda, it is much less than 100 feet thick, the coarser part only 10 or 15 feet, and the pebbles are no larger than a pea. As you go farther westward, the pebbles diminish to the size of mustard-seed, and the stratum of rock thins out until it disappears altogether. This shows very evidently the source from which the rocks of the coal-measures were derived, and that the ocean-currents which carried them proceeded from a southeast to a northwest direction.

In Michigan the thinning out of the strata toward the south indicates the source of the rock-making materials to have been in the north.

In Illinois the conglomerate rock is thickest and coarsest in the southwestern part of the field, thinning out and the material becoming fine along the Indiana edge of that field. Farther southwest, in Western Central Arkansas, the conglomerate has a vastly greater development, showing its proximity to strong currents and to the land of the ancient continent from which this rock was formed. There is also a great development of the conglomerates beneath the coal in Tennessee and Alabama, of which the celebrated Lookout Mountain is a conspicuous example.

The foregoing is given as the most plausible theory of the origin and formation of coal, and, while difficulties may suggest themselves to the reader, still that coal is derived from the vegetable kingdom admits of no doubt. This is one of the well-established facts in geology. The precise character of the process by which the change is brought about may not be perfectly understood, and there may here be room for further examination to fully solve this interesting problem. But no one can be long among the coal-rocks without recognizing the work of an Almighty Hand. With our feeble powers we can only see some of the means He used for the accomplishment of His purposes, and beyond that we must admit that, in some respects, the world of the past is as mysterious as the world to come.

Having before us and clear in our minds the foregoing explanation of the origin of coal from the luxuriant and extraordinary fresh-water vegetation of the coal-making age, we will now hastily advert to the various formations of rocks—not as a treatise on geology, but only with a view to detecting, if possible, those in which we should expect to find coal, as well as those in which it would be useless to search for it.

II.

THE ROCKS AMONG WHICH COAL IS FOUND.

The following plates give the names and descending order of the geological formations as they were formed and placed upon each other, not always in an horizontal position, for material carried by water must be deposited on whatever bottom may be ready to receive it, whether rough or smooth, sloping or horizontal. Neither are these formations of uniform thickness; on the contrary, they would naturally vary in thickness, owing to the exhaustion of the force of the currents by which they are carried, or the lessening of the quantity of the material transported by the water as we proceed from the source of the supply.

The geological sketch of the United States, on page 2, represents the area where each formation now appears on the surface. The four great coal-fields are on top, and overlie the Primary, the Silurian, and the Devonian systems. These systems, or larger divisions of the rocks represented on this map, are subdivided into the smaller portions given in the tables on pages 608 and 609. After the four great coal-fields and other older formations under them were elevated, and became dry land, the borders of the continent were enlarged by the formation of the Triassic, Cretaceous, and Tertiary formations along the Atlantic coast. The two latter are mostly of an earthy character along the eastern coast, like the sands which are now daily washed ashore by the waves of the sea, and without solid rocks. The whole country between the Missouri River and the Pacific Ocean is covered by these newer rocks of a more extensive and solid kind, formed after the Carboniferous or best coal-producing rocks.

Our subject lies altogether among the rocks, for there alone is coal to be found. For our present purposes, the formations may be divided into two classes, those that do and those that do not produce coal. It is, therefore, necessary to know the rocks among which coal occurs, and those among which it is never found. There are no more important propositions connected with our subject, and they are both equally important. They should, therefore, be examined patiently. All experience proves that only three of our great formations produce coal: 1. The Carboniferous. 2. The Triassic in a very few localities near Richmond, Virginia, and at Deep River and Dan River, North Carolina. 3. The transition beds of Hayden,[1]

[1] These will probably prove to be Cretaceous.

lying between the Upper Cretaceous and the Lower Tertiary. But what are the means by which these and other geological formations can be distinguished from each other? There are certain safe and infallible guides by which modern geologists determine the true order of the arrangement of the strata of the earth, or the order in which they were formed, and are enabled to identify them in different localities. The original order of the rock formations is never reversed, although sometimes one or even many of them are absent. "It is a history, some of whose leaves are certainly torn out." The irregular and broken condition, and the changeable, uncertain character of the same strata in different places, together with other insuperable difficulties, have rendered it often impossible to identify them by their position, lithological character, appearance, or composition. But the animal life of the globe has changed at various periods in the earth's history, and, as the species of life peculiar to each period was destroyed, it left imprinted in the rocks more or less perfect images of itself.

Epochs and Sub-Epochs.	
Pleistocene, or Post-tertiary.	
Pliocene.	
Miocene.	
Eocene.	
Upper Cretaceous.	Upper or White Chalk. Lower or Gray.
Middle Cretaceous (Upper Green-Sand).	
Lower Cretaceous (Lower Green-Sand).	
Wealden.	
Upper Oolite.	Purbeck, Portland, and Kimmeridge Clay.
Middle Oolite.	Coral-rag. Oxford Clay.
Lower Oolite.	Stonesfield. Inferior Oolite.
Upper Lias.	
Marlstone.	
Lower Lias.	
Keuper.	
Muschelkalk.	
Bunter-sandstein.	

Periods.	*Epochs.*
	Permian.
	Upper Coal Measures.
	Lower Coal Measures.
	Millstone Grit.
	Upper.
	Lower.
	Chemung.
	Portage.
	Genesee.
	Hamilton.
	Marcellus.
	Upper Helderberg.
	Schoharie.
	Cauda-Galli.
	Oriskany.
	Lower Helderberg.
	Saliferous.
	Niagara.
	Clinton.
	Medina.
	Oneida.
	Hudson River.
	Utica.
	Trenton.
	Black River.
	Birdseye.
	Chazy.
	Calciferous.
	Potsdam.
	Azoic.

Geology is a history of the former life of the globe as written in hieroglyphics upon the rocks, and is one of the most sublime and interesting of the natural sciences. The geologist repeoples the old rocks which were the sand, clay, and soil of the ancient world, with their former living tenants, reanimates their bones, makes them to live and move before us, and these are the only index by which he has been enabled to recognize the same rocks from place to place all over the world, or those equivalent in age.

A fossil is literally something dug from the earth, and the term is applied to those organic substances which have become penetrated by earthy or metallic particles, and are found in the earth or rocks. The sand, clay, and pebbles of which the rocks are composed, when being moved by currents of water, have carried with them and buried up fish, shells, plants, and animals, which existed when the rocks were forming.

As the organic bodies decomposed, particles of sand, clay, iron, or the surrounding material, immediately took their places, until the whole space was filled with new material, and we find a hard substance in the form of the original shell, fish, plant, or animal, which, in common language, is called a petrifaction. Paleontology is the science of the fossil remains of animals and plants now extinct. Those who have never examined a good geological cabinet have generally a faint idea of the perfection in which these organic remains are preserved, or the beauty and surprising size and curious character of the fossils. Large volumes of our State Geological Reports are filled with fine engravings of these "footprints on the sands of Time," which are as useful as they are ornamental. They have been also appropriately called the "medals struck by Nature to commemorate her revolutions." To which Huxley adds: "As it is the custom in these times to deposit the coins and medals of the age under the foundation-stones of a building, so the Great Artificer has, as He laid each course of stone in the world's foundations, deposited coins and medals of His striking, the remains of the then existing systems of organic life, the bones and shells of the contemporaneous living beings." Strange to say, the fossils in every formation differ in species entirely, or nearly so; or, are found in different proportions from those of every other formation; and, on the contrary, those of the same formation, the world over, are very similar in genera, if not in species, although the character of the rock may have changed, as from a sandstone in our Eastern States to a limestone in the Western States, or from the chalk-beds of England to the green sandstones of New Jersey.

There are sufficient causes for the wonderful identity of the fossils in contemporary rocks in the ancient geological formations when widely separated. Look at the engravings of the fossil remains of the true coal-measures at Newcastle in England, or Edinburgh in Scotland, and you find them precisely the same as those at Wilkesbarre, or Blossburg in Pennsylvania, in Tennessee, in Illinois, in Missouri, and in all parts of the world where the Carboniferous formation existed. The temperature of the atmosphere did not then perhaps depend, so much as it does now, on the

heat of the sun or the varying extent of the continents, but may also have been affected by the internal heat of the slowly-cooling earth. There was but one climate all over the parts of the earth where coal is now found, and no changes of the seasons, and the same mild temperature of the ocean; and hence the same kinds of plants flourished at the same time everywhere on land, and the same fish lived everywhere in the sea.

But paleontology is not a study of mere curious scientific inquiry, says Prof. Owen; it has also its practical inferences, and these of the most important character, with their direct, matter-of-fact bearings. In illustration of this view of the subject, he directs the attention of the reader to the fossil corals represented in one of the plates of his Geology of Iowa, etc., belonging to the sub-carboniferous limestones and near the top of the series, which are always under the true coal-bearing beds, never above these and included in them, and nowhere else. This geological fact holds good not only in Iowa, but throughout the entire range of the sub-carboniferous limestones in Indiana, Illinois, Kentucky, and Tennessee. In not a single instance, from the range of the Cumberland Mountains on the east to the interior of Iowa on the west, has a workable bed of coal been discovered in a position beneath the strata of limestone containing these corals. In these organic remains, then, we find the surest, the most unerring guide in the search after this invaluable article of commerce. Without the knowledge of this fact, millions of dollars might be expended and have been expended in fruitless and hopeless mining operations after geological incompatibilities.

The study of Dana's "Manual of Geology," or his smaller work, the "Text Book," or some similar work on geology, is earnestly recommended to those who need information on this subject. The limits of this volume will only admit of the foregoing list of the geological formations in the order in which they occur, and such discussions as relate to coal.

The preceding chapter on the origin of coal was first given in order to show clearly that coal can only be found in those formations which existed when a portion of the surface of the earth was elevated above the sea, and that, too, under the peculiar circumstances necessary for the accumulation of the vegetable matter of which coal-seams are composed. It is, therefore, quite important to know at what period in the world's history land-plants first appeared, and when the other conditions for coal-making were fulfilled. An examination of any geological cabinet, or of the engravings of the fossils which illustrate geological works, proves that, in all the older geological formations, no fossils are found but those of marine origin. In the Silurian age there has not been found a trace of any land-plants whatever. The Devonian age produced the first terrene vegetation, but no coal has ever been found in the Devonian rocks. These plants appear to have been only a few rare fragments, not at all equalling in quantity that of our own time, much less that of the Carboniferous age, or any in the least resembling it in species. A very extensive formation of black slate occurs in the Hamilton period, which is now be-

lieved to have originated another of the important mineral productions of our day.

In our search for coal we must now pause: for here is something that looks like it, in the Marcellus shale. This shale has a long range through the State of New York from Lake Erie eastward, and through Pennsylvania and Virginia. Some portions of the lower strata are black and friable, containing some particles of carbon, derived from sea-weeds, which made these shales the object of search for coal. Very small quantities of coal have been found in them, which were considered sure signs of the existence of large bodies.

Sometimes specks or particles of coal have been found in the joints or cracks in the rocks. Borings hundreds of feet in depth were made in these rocks in search for coal. Very black slate is found mixed with coaly material and minute veins of coal. Portions of the shale are found highly glazed, with here and there an accumulation of coal, rarely exceeding a few inches in length, an inch or so in width, and a quarter of an inch in thickness. The rocks are simply formed of argillaceous and calcareous mud, blackened with a little carbon from a few carbonized seaweeds. Practically, it is not of the slightest value; but, scientifically, it is highly interesting to us, as the first indication of Nature's intention to proceed to her great work of coal-making after the formation of the next great sandstone. It should be remembered that there has not been discovered in any of the preceding rocks the slightest vestige of a terrestrial plant, of which the earliest fragment now occurs in the Marcellus shales. Although the Hamilton and Marcellus shales contain merely traces of land-plants, and will produce no coal, there is little doubt that they are the source of that great wonder of our age, petroleum. The rock-oil of Canada, Northwestern Pennsylvania, and West Virginia, seems to have been generated by the transformation of the organic matter in the strata in which it is found. It is believed to have been formed from marine plants, just as coal is derived from terrestrial vegetation. It also requires a basin form of the rocks for its reception and preservation in a body in a liquid form; but as the basin in which coal is found is below, that required for oil is above or inverted, the oil having a tendency to rise upon the water as well as from the force of the gas which accompanies it. An impervious rock or bed of clay over it is therefore one of its requisite conditions. The following is Prof. Lesquereux's account of the origin of petroleum:

"And what is petroleum or mineral oil, which is now entering in our civilization, if not as one of its essential elements, at least as one of its potent auxiliaries? It is, like coal, the result of slow maceration of plants; with this difference, that, in the formation of the coal, the plants which entered into the composition of the matter were woody or fibrous, and the woody tissue cannot be destroyed by the slow process of combustion any more than it is in burnt charcoal. The plants which concurred to the formation of petroleum were sea-weeds or marine plants. These have no

fibres, no wood in their tissue, which is merely cellular; and in their decomposition all trace of this tissue has been destroyed, and pure bitumen preserved, either by impregnation of shale or sandstone, etc., or by accumulation in subterranean cavities. It is to fossil plants also that we owe the explanation of this remarkable process of mineralization. Deposits of oil are especially found in strata of the Upper Silurian and the Lower Devonian, and always in connection with shale or limestone, which contain in great quantity petrified remains of fucoids or marine plants. The conditions bringing up an exuberance of vegetation were already at work before the Carboniferous epoch; their action resulted in the production of an immense marine vegetation. As Nature does nothing in vain, as she takes care of all her materials and uses them, to the minutest *débris*, she took the bitumen away and preserved it in cavernous recesses for future use. By the discovery of our deposits of petroleum we have learned what had been done with the superabundant production of marine plants in our old geological epochs. Coal and petroleum are found in all the geological formations. But since the coal era the deposits of these matters have become of comparatively rare occurrence, and of far less importance, their value being diminished as much by the reduction of their areas as by the inferior quality of their products. They now take a nominal and far more modest place in the harmony of our earth's surface."

In the Chemung group we find a second symptom of coal: "Many of the thin sandy layers of the Chemung group are often almost covered with small fragments of carbonaceous matter, apparently derived from terrene vegetation. These seem to have been comminuted fragments of vegetation, brought down from the continents or islands on the east, and, being spread evenly over the surface of water, were distributed widely, and deposited with the sand and mud.

"All facts of this kind are interesting, as showing an approach to that period when terrene vegetation flourished on a grand scale, and in its distribution gave origin to the great coal-measures of the United States. Throughout all the lower rocks of the New York system there is no evidence of terrene vegetation, and consequently no proximity to coal-bearing strata, and it is only subsequently to the deposition of the formations of this system that this kind of vegetation appears."—(Hall.)

None of these coal-traces are found farther west than Eastern Pennsylvania. Hence, it is inferred that the locality of these carbonized seaweeds was somewhere in the East, whence they have floated and settled down with the mud of the Chemung period.

The history of the dawn and progress of land-vegetation is thus sketched by Prof. Lesquereux, in Hayden's Report on the United States Territories:

"As most of the strata composing the crust of the earth have been formed under water, and mostly contain remains of animals, especially of mollusks, geology receives from animal paleontology far greater assistance, for the determination of the strata and of their relative age, than it can

obtain from the study of botanical remains. Considered in this point of view, therefore, fossil-plants appear of little importance. But when we come to demand from geology some instructions, some light concerning the surface of our earth at different epochs, science can answer nothing if it does not inquire into the data furnished by botanical paleontology. As vegetation is in absolute relation with atmospheric circumstances, the fossil plants are, indeed, the written records of the atmospheric and physical conditions of our earth at the epochs which they represent. In the Marcellus shale of the Middle Devonian, we see the first appearance of vegetation in the fossil remains of large trunks of coniferous trees found here and there embedded in the shale, without any trace of branches or leaves. The shale also contains a quantity of fish-remains, and large flakes of black, coaly matter, apparently due to the decomposition of marine plants. It is an extensive formation, sometimes a few hundred feet in thickness, impregnated with bitumen, presenting everywhere the same characters. No other trace of land-plants is left but these large fossil trunks. Where was the land then just emerging for the first time from its marine cradle? What was the aspect of the landscape? A black, muddy surface, covered with an atmosphere darkened by vapors, where nothing is distinguishable, but perhaps, at wide intervals, a group of some trees emerging from the muddy bottom and breaking the universal gloom. No trace of animal life appears above the waters. All is dismal and silent.

"In the Upper Devonian, the Chemung, the Catskill group, and especially the red shale of the sub-carboniferous measures, largely developed in the anthracite basin of the Appalachian coal-fields, the remains of land-plants are more frequently found. These are not trunks of fossil wood, but rather leaves and branches of a peculiar type of plants, ferns with flabellate leaves, especially *Noeggerathia*, which we do not find in the coal-measures; and a few stems of *Lycopodiaceæ* and *Equisetaceæ*, the first representatives of a class of plants which constitutes the largest part of the vegetation of the coal. Leaves and branches of the Upper Devonian, and sub-carboniferous measures, are compressed between layers of shales, which bear ripple-marks, fissures caused by heat, and round prints, evidently formed by drops of rain. If this does not indicate a succession of seasons of different temperature, it shows at least a distinct atmosphere, already penetrated by light, where changes of temperature cause condensation or diffusion—rain, followed, perhaps, by some rays of sunshine. Animal life also appears at the surface; crustaceans and large creeping saurians slowly plough their paths in the mud. Their traces have been preserved upon the shales; they indicate the first attempt at an aërial respiration.

"In the coal formations the aspect of the landscape is totally changed. Everywhere the vegetable life predominates, and attains its widest proportions; all still more or less under the influence of water. The emerged land is marked by a succession of immense low swamps, whose surface is concealed under a thick carpet of creeping plants, which fill them with their *débris*. Where the land has already some fixity, immense forests of

large trees, mostly of the acrogenous kind, grow in a dense mass, of a size and height which compare with the largest trees of our time. They cover the land with a world of vegetation, which is scarcely now conceivable, even by the wildest imagination. All the vegetation is, by its nature, its form, its texture, especially adapted to the absorption of atmospheric humidity and of carbonic acid. It is there at work cleaning the atmosphere, in transforming into woody fibre its surplus of water, and of carbonic acid, and preparing it for animal life. For, already, remains of saurians, scorpions, insects of large size, found in the shale of the coal, indicate that animal life has taken a marked place on the surface of the land. There is there, also, an evident distinction of seasons; the layers of coal show annual decay and periodical deposition of woody remains.

"The Lower Permian has still for its land-vegetation many species of plants of the coal-measures, but here the conifers appear, represented for the first time by their leaves and branches, and are of a peculiar order. The carboniferous vegetation loses its force by the disappearance of its arborescent acrogenous plants. The *dēbris* are no more heaped in immense deposits, but scattered here and there in the shales, or forming by their agglomeration mere flakes of coal. This indicates an atmosphere already discharged of its greatest part of carbonic acid, and of vapors. The Triassic, which, with us at least, touches, by the character of its flora, to the Jurassic, has plants which, like *Cycadeæ*, rather indicate a warm than a vaporous atmosphere. But for this and the following formations, the Jurassic, the data furnished by fossil plants on this continent are too scant to permit reliable conclusions. We have to pass to the lower cretaceous to find abundant remains of land-plants, and here at once we have a vegetation absolutely different in its characters from all that has been seen before. All the forms (the needle-form of leaves) which indicate atmospheric humidity have disappeared; scarcely any conifers remain, very few ferns, no trace of *Lycopodiaceæ*, but leaves of dicotyledonous plants, representing already most of the genera of trees found in our forests. The vegetation is therefore of a kind known to us. The atmospheric circumstances are then analogous to those of our time. We now follow through the Cretaceous and Tertiary formations merely modifications of species, disappearance of some forms, reappearance of others, about as we should have to do now in studying our flora in passing through a few degrees of latitude."

Two questions in geology we have already said are important to our subject, namely, In what rocks may coal be found, and in what other rocks is it never found? The answers to both are extremely important in order to prevent the useless expenditure of time, labor, and money, in searching for coal in parts of the country where it cannot possibly exist. If any fact can be said to be positively well established in geology, it is this, that no coal has ever been discovered, and therefore, as diligent search has been made, we are justifiable in believing that none need be looked for, in any of the rocks which are below the Carboniferous formation.

In the final report of the Geological Survey of the State of New York, Prof. James Hall gives the following judicious advice. All the formations below the coal-measures are better developed in that State, probably, than in any other part of the world. The reports describe them all minutely, from the Azoic up to the Carboniferous, of which only a projecting point of the conglomerate underlying the coal was found extending a short distance over the State line from Pennsylvania.

"Since it is well ascertained that coal of the true coal formation does not exist within the limits of the State of New York, it may be well to state the position in which this mineral may be sought. Along the Hudson and in various parts of the Hamilton, Portage, and Chemung groups, immense amounts have been expended in search of coal. In the western part of the State almost every rock containing carbonaceous matter or possessing bituminous odor has been bored or excavated for coal. Black slates, some of them highly bituminous, have been found, and thin seams of coal do sometimes occur, but they rarely extend beyond a few feet, and are usually less than an inch in thickness. These seams or strings of coal are not indications of its existence in large beds, and the appearance of the strata, though ever so similar to that about coal-mines, cannot alone be relied on.

"In all the situations where coal-beds occur the shales and shaly sandstones contain the remains of land-plants like ferns, often in great abundance; and the absence of these in strata with the occurrence of certain marine fossils may be looked upon generally as conclusive evidence of the absence of coal. The organic remains of these strata thus become of the utmost importance in identifying their position. This negative knowledge of the absence of coal in any region is of the utmost importance; for, although it may not enrich the possessor as much as a coal-mine, it will still enable him to avoid a useless and wasteful expenditure in search of that mineral, and set at rest a vain expectation which has cost an immense expenditure in time and money. All the workable coal-seams of the country are confined to the Carboniferous formation, and none have ever been known to occur in the rocks previously described."

He then goes on to describe the conglomerate which is found in place in Cattaraugus County, New York, and consists of a mixture of coarse sand and white quartz pebbles, varying from the size of a pin's-head to the diameter of two inches, and are generally oblong or a flattened egg-shape. Only six miles south of the New York State line, on a high ridge of land between the Alleghany River and the Conniwango Creek, a bed of coal lies upon the conglomerate, which latter extends thence northward into New York, its broken outliers appearing for 10 or 15 miles north of the State line.

This conglomerate forms the margin and immediately underlying rock of the coal-measures. Tracing it westward to Ohio, Indiana, Illinois, and Kentucky, and southward through Pennsylvania, Maryland, and Virginia, we find it holds the same relation to the rocks of New York and to the

coal. In Ohio the absence of the Old Red Sandstone brings it directly in contact with the Chemung group.

"These facts," says the learned professor, "are of the highest interest, both in an economic and scientific view, for, since the extent of the conglomerate is so well marked and widely known, it may in all places be relied upon as indicating the proximity of coal."

In Pennsylvania, too, the hard, black mud of the Hamilton period has been dug into for coal, as Prof. Lesley tells us, "in the upper valley of the Delaware and Schuylkill, and in many other places men have spent years, long lives in fact, in digging vainly into this black slate for coal. Instances are well known where fortune and reason have sunk together in the search."

According to Cook's geological report of New Jersey, coal has been found in the New Red Sandstone of that State in seams from an eighth to half an inch thick in several places. Enough has been seen to induce persons to bore for it. Occasional layers of the rock have been found that were dark-colored and bituminous, from the presence of vegetable matter enough to make the shaly rock give off combustible gas when heated. These appearances have deceived many. The fossil plants found evidently belong to orders higher than those of the Carboniferous age, and the footprints found are those of air-breathing animals, probably of the Reptilian age.

The Triassic or Red Sandstone formation contains the bituminous coal-beds of Richmond, Virginia, and Deep River, North Carolina; but in New Jersey only thin seams have been found. Some boring has been done in search for coal, but without success. The country occupied by this formation is so cleared up and the opportunities for thorough exploration of its rocks are so good, and so numerous, that we cannot now hope to find any valuable coal-beds in it.

Lignite or brown coal is found in the plaster clays of New Jersey. Sticks of wood having the appearance of coal are very common. This fossil wood or lignite is combustible, but has not usually been found in sufficient quantity to be of much importance. Seams of it have been found 18 inches, and in one locality even four feet thick. All the attempts at mining this coal have been abandoned, as might have been anticipated by any one acquainted with mining operations and the peculiar character of the fuel obtained.

The same deceptive appearances of coal have been observed in Canada, as we are told in their Geological Report. In the lower part of the Gaspé sandstones or Hamilton group in Canada, is a well-defined seam of coal, with carboniferous shale, measuring together three inches. A terrestial vegetation prevailed throughout the whole series, yet in no other part of the thickness of 7,000 feet was there observed a distinct seam of coal. The same Upper Devonian strata, in the State of New York, contain, in like manner, thin seams of coal which are of no economic importance.

The black shales of the Portage and Chemung group, in some localities,

contain so much organic matter as to take fire and burn with flame, after which the color is changed to a brick-red. This is observed in the shingle of the beach, which has evidently been subjected to fire, and it is reported by the Indians to have continued burning for some time.

There is not a State in the Union in which the Hamilton slate is found in which large sums have not been expended in foolish searches in it for coal, as has been several times noticed in this volume.

From England and other countries we have the same story of the waste of money and labor in the foolish attempt to find coal in the older rocks. Hugh Miller tells us: "The time and money squandered in Great Britain alone, in searching for coal in districts where the well-informed geologist could have at once pronounced the search hopeless, would much more than cover the expense at which geological research has been prosecuted throughout the world. There are few districts in Britain occupied by the secondary deposits in which, at one time or another, the attempt has not been made. It has also been the occasion of enormous expenditure in the south of England among the newer formations where the coal, if it at all occurs (for we occasionally meet with wide gaps in the scale), must be buried at an unapproachable depth. But in all these instances there are strongly-characterized groups of fossils, which, like the landmarks of the navigator, or the findings of his quadrant, establish the true place of the formation to which they belong. Like the patches of leather, of scarlet and of blue, which mark the line attached to the deep-sea lead, they show the various depths at which we arrive."

Thus much space has been given to this subject in the hope that some reader of these pages may be thereby spared the disappointment and loss attending fruitless efforts to find coal in rocks where science and experiment have proved that it does not exist. In many cases the warning will be unheeded, for thousands will learn nothing but in the expensive school of their own experience. The most costly sacrifices are always offered to the false gods. Those to ignorance and folly far surpass all that have ever been made to science.

III.

THE CONDITIONS OF SUCCESS IN THE COAL-TRADE.

THE mere buying and selling of coal do not differ from the traffic in any other coarse commodity. The term coal-trade, however, is here used in its more extended sense, as including all the branches of business connected with the producing, the transportation, and the selling of coal. Many companies, as well as individuals, who have engaged in this business, have been unsuccessful. It is, therefore, quite important to know how they might have succeeded. A correct knowledge of the true principles relating to any branch of business is indispensable, and in none is it more important than this.

The requirements which constitute a valuable coal property, and a successful coal-trade, may be briefly summed up in a good quality of coal, in sufficient quantity, cheapness and regularity of production, cheapness and sufficiency of transportation, a good market, sufficient capital, and good management. Here are nine conditions which lie at the foundation of the coal-trade; all of them are essential to success, but some of these terms should be understood relatively. Let us examine them in detail:

1. Coal may be of a good quality, commercially, in Missouri or Illinois, where there is none better to be had, or where its cheapness protects it from competition from better and more expensive coal, while it would not be worth mining in Pennsylvania. The good or valuable quality of coal, too, depends on the uses to which it is applicable. For example, one that answers only for domestic or household use, or for making gas, must be within a cheap distance of a considerable population which needs it, and a coal that is only useful for manufacturing purposes is only valuable in a manufacturing country, or within a cheap distance of it. In every point of view a good quality of the coal is a fundamental condition, and nothing will fully compensate for the want of it. In America especially, people will buy the best fuel that can be had; a low price weighs but little against poor quality, and no prudent man should attempt to work a mine of poor coal, to be placed in competition with a full supply of a good quality, without expecting to sell his commodity at even a lower rate than its relative value would seem to require. This is especially true of domestic coal, as shown in the universal use of anthracite wherever it can possibly be had,

and of coals adapted to special uses, such as Cumberland and Blossburg, and the gas-coals of Western Pennsylvania. The growth of the anthracite trade to 19,000,000 tons within fifty years, it having nearly doubled in amount for each of the last ten years, is chiefly owing to its excellent quality. It is true its vicinity to the seaboard market affording abundant and cheap transportation, and the cheapness of its production, were great advantages, but back of all these was the intrinsic value of the fuel, which has created for it a market at every hearth, and made it the basis and creator of many of our great manufacturing interests.

So, too, the growth of the Cumberland coal-trade to nearly 2,000,000 tons, situated as the region is, so far inland, 206 miles by railroad from Baltimore, and 191 miles by canal from Alexandria, and all of it carried to tide-water, is a conspicuous example of what can be done with coal of a good quality. The Blossburg, McIntyre, and Towanda coal-trade, which was 1,403,531 tons in 1872, sold wholly in the State of New York west of the Hudson River, and in the Western States, and some of it finding its way to the Rocky Mountains, but chiefly used in the interior for steam, for rolling-mills, and blacksmithing, is an instance of the value of particular qualities in coal, which, until the growth of manufacturing and the use of steam called for them, were of little or no value.

It would be a very instructive lesson to those who are capable of being taught wisdom by the history of the past, to look over the reports of the multitude of coal-companies which have at various times been formed, and to see the large fortunes which have been spent in most of our coal-regions in opening mines, building canals and railroads, and other preparations for an extensive coal-trade which never was obtained. While it is very easy to fail from the want of any of the conditions above named, as well as from some other causes, yet it will be very often found that the want of coal equal in quality to the best offered in the market has been a very fruitful cause of failure.

2. The sufficient quantity above mentioned depends on the expenditure of capital required to develop the coal and place it in market, such as the cost of opening the mines, of building railroads, and similar circumstances, which will readily suggest themselves to every one.

3. The cheapness of mining (and the same remark applies to transportation) depends not on the actual or nominal sum paid, but on the price received for the coal as compared with its cost, and the capital invested, and the cost of living generally. Wages which would be very high now, would have been cheap during the late war, when coal brought a good price. In the production of coal from the mine there are, after the mine is opened, four important items of expense, the cutting or mining of the coal, getting it out of the mines, including breaking and cleaning it ready for use, keeping the mines secure and free from water, and supplying them with fresh air. The first two are obvious to every one; but those who are unacquainted with mines have no proper idea of how much it costs to keep the miner's feet dry, and to supply him with air to breathe.

4. Irregularity of production has been so ruinous to those who have suffered from long strikes, as is very obvious, especially to all operators in anthracite coal, that it would be improper to dwell at length on so painful a subject.

5. *Transportation.*—Coal which, from its location, is without any market in its vicinity, and without any means of transportation to a distant market, is of no present commercial value; and, for our purposes, may be allowed to pass as a part of the great stock of fuel laid aside for posterity. Our own share is that which can be brought within reach of the consumer. In regard to cheapness of transportation, it should be noticed that, in trade, distances must be computed by dollars, and not by miles. From Buffalo, New York, to Chicago, Illinois, the distance by the lakes is more than a thousand miles. But anthracite and Blossburg coal are there carried by tens of thousands of tons, for fifty cents per ton; sometimes for forty, and it has seldom cost over one dollar previous to the year 1872. On the other hand, coal was for many years reshipped from canal-boats into railroad-cars at Cayuga Bridge, and sent to Auburn, New York, by rail, a distance of eleven miles, at a cost of eighty-five cents per ton. Therefore, commercially, these two places are farther apart than Buffalo and Chicago, where, geographically, the distance is one hundred times as great. Similar instances may be seen in the case of cheap water transportation on the Erie, the Raritan, and other large canals, and in coastwise freights by vessels, as compared with railroad charges. The longer the distance by the same mode of carriage, the cheaper is the cost per mile, as less time is lost at the end of the route in a given time, in loading and discharging. Grades on railroads and locks on canals are also involved in the question of time occupied, and labor to be performed; and another point is, whether or not the transporter has a return-freight. The cost of the railroad or canal, on which cost dividends must be paid, is involved in the question of the proper cost of transportation. Competition among transporters, in the absence of combinations, reduces prices; but a monopoly of transportation is not necessarily attended with high rates, if the transporter is governed by enlarged and comprehensive views of business, and aims at a large tonnage, which, at low rates, is better for him than a smaller tonnage at a higher rate. The multiplication of roads or avenues to market is not necessarily an advantage, as, by dividing among several the work which could have been done cheaper by one, the cost of doing it is actually increased by the employment of an unnecessary amount of labor, machinery, and capital, all of which must, in the end, be paid for in some way out of the proceeds of the coal. The regularity of the supply of freight for transportation throughout the year is an important consideration; as, otherwise, the transporter must be compensated in his charges for the time his labor and the facilities he has provided are not employed.

6. A *sufficiency* of transportation is not the least of the many important requirements of this trade. Nothing is more common than for companies and individuals, embarking in this precarious business, to be ru-

ined by the want of sufficient transportation alone, when all the other conditions are fulfilled. Our country is large, our customers are found at distances of hundreds, and sometimes thousands of miles, and our coal must be taken to them. These excessive distances to where the coal is to be consumed is one of the most important elements in the business. However strong you may be in other respects, if you are weak in transportation you never can succeed. Scarcely any other article which is transported is so heavy according to its value; the profits on each ton, at best, are but small; and you must, therefore, have ample means of transportation, to fill your orders whenever the demand may arise, or you will make no money.

7. *The market* for coal may be said to be good, when it absorbs at a good profit all that is produced; or, in other words, there should be a demand for a sufficient quantity, and at a remunerative price. Many a mine has been opened, railroads and canals built, and the proprietors have only discovered, when they have carried their coal into the market, that it was not wanted. The first Lehigh coal sent to Philadelphia, in the year 1803, being considered worthless, was broken up, and used on the sidewalks; and when Charles Miner sent his first ark-load of the same coal to market in 1814, which cost him $14 per ton, the experiment was almost as unprofitable. This, in a less exaggerated form, has been the experience of almost every pioneer in the coal business. Sometimes, the selling agent of the first shipments has been obliged to tell the customers what the coal was, as well as to instruct them how to burn it. As a rule, the early coal-miners were unfortunate, or were obliged to wait for years until a market was created, and a demand sprung up for their production. On the other hand, if a demand exist, the market may be fully supplied by others who consider that the trade which they have built up belongs to them, and, from an excessive production, a competition immediately arises which reduces the price below a paying rate. Competition for the market is another source of the ruin which has often attended the coal-trade. This is an exceedingly important branch of this subject. There are two points to it: what is now done to prevent competition, and what it is right to do, having a proper regard to the rights of the public. It is often said, that prices should only be regulated by the law of supply and demand; but experience shows that they are also influenced by other considerations; for example, the weakness and folly of the seller. Against these he endeavors to guard himself, by combinations with those of the same trade, in one form or another.

As human nature is everywhere the same, we find that in England, at a very early period, to prevent the ruinous competition among those engaged in selling coal, an association of the coal operators, called the "limitation of the vend," was formed in 1771, and continued till 1845, in order to regulate the quantity of coal produced, so that a remunerating price could be procured. Another part of the system was the buying up of coal-lands or the privilege of mining the coal, and paying an annual royalty, although no coal is mined, in order to prevent the market from

being demoralized by new operators through their anxiety to sell their coal.

In this country the same purpose is more effectually accomplished, by the consolidation of the coal-business in the hands of a few large companies incorporated by law, with power to hold large bodies of coal-land, to mine and sell, and in some cases to buy and deal in coal, to build railroads and transport coal to market. While, in the districts where a large number of individuals are mining and selling coal, nothing is seen but a succession of failures, and frequent long suspensions of business, on the other hand, these large corporations are successful, and the districts where their operations are conducted are highly prosperous. Thousands of industrious persons find constant employment, in a thousand different vocations, all founded on the coal-trade. The general results are obviously beneficial to the public interests. Individuals may complain that they are deprived of their natural rights, in being practically unable to mine their coal, send it to market, and sell it as they think proper, and that they are obliged to sell their coal to the large companies. But the reply is, "You have the right to build a railroad to New York or elsewhere, and can procure the same corporate rights for yourself as these companies enjoy."

These associations of individuals have a right to the exclusive enjoyment of the fruits of their own united capital, whether expended in a coal-mine or a railroad. In this country, a sufficient sum of money cannot otherwise be obtained, to develop on a proper scale our great coal-mines, transport the coal those long distances to market, and furnish the large amount of necessary working capital. In one of our finest coal-fields, that of Schuylkill County, the system of having the transportation in the hands of a company, and the coal all mined by individuals and firms, proved an utter failure, and appearances indicate that, before long, all the branches of the business will be conducted by a single company, which now owns 95,669 acres in the first and second coal-fields.

The preventing of injurious competition is not here stated as the object in view in the forming of the large coal companies referred to, but only as one of the incidents attending them. And now the question arises, How do they affect the public interests? Are we building up dangerous and oppressive monopolies, which may use their power by exacting an extravagantly high price for their coal?

It would be useless to discuss this question, it is too late. These companies have become one of our established institutions; the advantages they offered for the development of the material interests of the country were believed to outweigh any danger from a monopoly in anthracite, especially as it is impossible that any such monopoly can also be obtained of our boundless fields of bituminous coal.

But what has been the practical working of the system?

As a general rule, there is nothing so useful, that is furnished so cheaply in America, as coal. Where the anthracite trade is in the hands of

large companies, as in New York City, Syracuse, Rochester, and Buffalo, coal is retailed at nearly the wholesale prices, and the fluctuations in prices are less than under the competition system, where the dealer must indemnify himself for severe losses, when coal is run down below a paying rate, by excessive prices when an opportunity offers. The man of means then buys his year's stock of coal at the lowest rate, and the poor, who must buy in smaller quantities, must pay for the coal of their wealthier neighbors. The large coal companies are confident in the strength of their position, their interests are identical with those of their customers, or, in a large consumption, they can make large expenditures to cheapen the production, transportation, and selling expenses, and can and do sell cheaper than if the business were more divided.

8. *Capital.*—The expenditure of capital required in the coal-business is enormous, and for the risks run, and amount of bold enterprise exhibited in opening mines, building railroads, canals, docks, and a thousand other ways, this great trade has received less reward in this country than any other branch of business. Of course, men have made money in buying and selling coal, as they have in lumber, cotton, grain, or stocks.

No reference is here made to coal as an article of traffic, but only to its sale by the producer. As a general rule, the first stock or the original capital expended by firms or coal companies has been totally lost, and only some fortunate successor, who has purchased the property at a fraction of its original cost, has made dividends. The history of the coal-trade of Schuylkill County, Pennsylvania, with its numerous failures, during the last forty years, would prove the above to be but a feeble and inadequate statement of facts. Even most of the large, and now wealthy corporations engaged in mining, transporting, or selling coal, have gone through seasons of difficulty verging on bankruptcy, and, while the companies have survived and retrieved their fortunes, many unfortunate stockholders have lost heavily in those investments. This has been chiefly owing to the want of sufficient capital. The building up of the present coal-trade has been a work of time, and, besides, the business is of a very complicated and extensive character. From the first exploration of a tract of land in search of coal, down to the receiving of the money arising from its sale to the consumer, is a long account, containing numerous items, every one of them being a charge of money expended in large sums. The credit side is but a single item, arrived at after a long time, through the successful working of a very complicated and extensive series of machines, each of which must act with the greatest precision, or a failure is the result.

9. This brings us to consider the ninth and last division of this subject. Not only are many undertakings of this kind begun unwisely prematurely, or without sufficient capital, but they are sometimes very badly managed. Persons engaged in other kinds of business are attracted by the idea of digging untold wealth out of the ground, and rashly invest their money, without the slightest knowledge of a single branch of

the coal-business. Its management is perhaps confided to men equally ignorant of their duties, and incapable of learning, or who acquire their education at the expense of their employers, by costly experiments. The extensive mining operations of this country, the great railroads involving the expenditure of millions, or even the mercantile branch of this important trade, cannot be properly conducted by men totally ignorant of every one of the arts, sciences, professions, and pursuits involved, or without calling to their aid those who are qualified. The mere physical prerequisites above enumerated are not more necessary than those of a moral and intellectual kind, good management, education, the necessary talents for business, knowledge of its details, experience, and skill, combined with industry, energy, and integrity. It has been often argued that individuals can manage the coal-business better than corporations. No doubt an individual may be able to economize in a limited business within his own oversight better than officers working for salaries usually do. But it is seldom that individuals possessing the necessary capital have also the business qualifications and experience above described, and are willing to apply themselves closely to business. It would be saying too much to assert that corporations always succeed in getting the right man in the right place, but when they do not it is their own fault, as they have the opportunity to select agents fitted for every duty, and the success of some of them is no doubt owing to their securing to their service the best abilities for each particular branch of their business.

But, unprofitable as it is sometimes to the producer, the public are always benefited by coal-mining. Without following it out in its more remote bearings, its more immediate results are the distribution among the people, for labor and provisions, of an amount of money equal to the cost of raising and transporting the coal to market, thus affecting the general prosperity of the country. The formation of a home market for all the produce of the country, the employment of numerous tradesmen, merchants, farmers, and all their families, and the general improvement of all the surrounding country in value and property, is the result. The anthracite coal alone mined in 1872 did not cost less than $70,000,000 by the time it was delivered to the customers. All of this money is the result of productive industry, and that sum was added to the wealth of our people. But it would be impossible to describe the vast number of persons who, directly and indirectly, are indebted to this great interest, not only for the comforts, but the very necessaries of life, food, fuel, raiment, and shelter.

It is sometimes useful to put together, in a methodical form, obvious facts like the foregoing, which are intended to show how many and how minute are the circumstances requiring to be attended to, in order to secure success in the coal-trade.

IV.

THE COMBUSTION OF COAL.

OUR task is not finished when our coal is discovered in the ground, mined, carried to market, and sold. The success of the business depends on its intrinsic value, and proper application for the useful purposes of life. There is scarcely any thing that is so much wasted as fuel, and there is no better field for scientific discovery and mechanical improvement than in the combustion of coal. It would be taking a very narrow view of the subject to suppose that it is to the interest of the producers of coal that it should be wasted, for experience has proved that every improvement which has aided in economizing fuel, and thus adding to the power and real value of coal, has increased the consumption, and thus benefited the producer as well as the consumer. The improvements made by James Watt increased the power of the steam-engine seventy-five per cent. with the same amount of fuel. This brought the engines into more general use, and, instead of lessening, it increased the demand for coal a hundred-fold. So, too, the application of the hot-blast to furnaces, in 1830, and every other improvement tending to cheapen the production of manufactures by saving a large portion of the fuel, have so increased the various kinds of manufacturing business that, instead of saving it, they have invariably led to an increased demand for coal, which is the food and life of industry.

In almost every important kind of manufacture, heat is one of the principal agents employed, so that the cost of fuel, in many cases, determines the cost of production. Every other mode of obtaining power has proved to be more costly than the use of steam from the combustion of coal, and the improvement of the methods of burning it, so as to obtain a greater degree of power from the fuel used, is, therefore, one of the most important subjects which can engage the attention and occupy the energies of a manufacturing and commercial people. It can easily be made evident that there is yet an opportunity for introducing more economical methods of consuming fuel, and the man who shall effect it will certainly deserve the gratitude of every consumer and producer of coal. The history of improvements shows that many of them have been made by those of different callings from those they have improved. Perhaps some one, who has never burnt coal on a large scale, may first see the way of cor-

recting our vicious methods—his mind being free from the dominion of erroneous habits. As this is a scientific subject, the writer will not indulge in any crude and delusive speculations of his own. The following principles are compiled from the latest scientific works on the subject, which he has merely digested and arranged; and they will be found to be supported by the best authorities:

The important artificial source of heat with which we are concerned, the combustion of coal, is, like many others, a chemical combination. It will illustrate it to refer to animal heat, which is also of chemical origin. The carbon and hydrogen of our food are placed in the presence of the atmospheric oxygen in our lungs, in the act of respiration, and thus chemical combinations are effected in our blood, attended with the disengagement of heat. Animal heat is thus generated by slow combustion, through the process of breathing. We inspire oxygen, and exhale carbonic acid and vapor, and the corporal mass undergoes a corresponding diminution for each definite quantity of carbon and hydrogen that leaves the body. This loss is replaced by the reception of food. If the person performs some labor, the consumption of oxygen and the reduction in weight are more sensible. Part of the oxygen is spent in the production of the labor or mechanical effect, and a part only in the production of animal heat, although the latter is, no doubt, augmented through the accelerated breathing and more rapid pulsation.

The burning of coal being, as already stated, strictly a chemical process, the principles of that science must be applied to it. Combustion, in this sense, is the chemical union of the combustible with oxygen, attended with the evolution of heat. When coal is analyzed, it is found to consist of certain elements—such as carbon and hydrogen—which, for heating purposes, are its only valuable constituents. It also contains others which are of no value, and from which no ingenuity can generate heat, such as earthy matter which remains in the form of ashes, or sand and clay, which form clinker, etc. No heat can be developed from coal without oxygen, which must be furnished from the atmosphere. A definite quantity of oxygen must be furnished for a definite quantity of hydrogen, also a definite quantity of oxygen for a fixed quantity of carbon, or the proper chemical combination will not take place. Here, then, are three elements for the production of heat; two of them, the carbon and hydrogen, cost money, while Nature freely furnishes the oxygen everywhere; yet, strange to say, there is scarcely a coal-fire where a large portion of the two expensive elements are not wasted for the want of a sufficient supply of the third, which costs nothing. In recent times, great improvements have been made in the lamp, by the proper admission of air, thus producing improved combustion. The same thing should be done for the stove and furnace, for the same chemical and mechanical principles apply. When the draft of a stove or furnace is closed, or when the fire is covered with ashes or fine coal, to use a common expression, the fire is said to be smothered. Unfortunately, nearly every fire is more or less smothered, so

far as utilizing the fuel is concerned, by an insufficient supply of air. It should be, first, distinctly understood that neither carbon nor hydrogen is in itself combustible: but that their combustion is their chemical union with oxygen, and that, to utilize these valuable materials, they must be properly brought together, and in exactly the proper proportions. For example, coal, containing carbon and hydrogen, is thrown into an air-tight iron retort in a gas-house, and subjected to the heat of a fire beneath; but neither the hydrogen nor carbon is consumed, from the want of the necessary oxygen—they are merely separated; the carbon is afterward removed from the retort in the form of coke, while the gas has passed into the receiver, and is afterward consumed by combining with the oxygen of the atmosphere in the gas-burner.

The process of burning coal may be first briefly and generally described thus: Before coal can be consumed it must be decomposed, just as it is in the gas-house. Nature first proceeds to analyze it, after it is thrown on the fire, by separating the hydrogen which it contains from the carbon. The hydrogen, having a stronger affinity for oxygen than carbon has, hastens forward, as it were, carrying some carbon with it, and is first consumed in a gaseous state by uniting, at a proper temperature, with its proper proportion of oxygen, and forming water, which passes off as aqueous vapor or steam from the chimney. The carbon, or coke, having waited its turn, is afterward consumed in a solid state, by also effecting a chemical union with oxygen, and forming carbonic-acid gas, which passes off in the same way. In burning coal, which contains hydrogen and carbon, then, the object to be attained is to convert the former into water or steam, and the latter into carbonic-acid gas; and, to effect these purposes, a very great quantity of air is required, inasmuch as the atmosphere is largely diluted with nitrogen, four-fifths of its volume consisting of this other material, which is a hinderance for our purpose. By weight, the proportions of the atmospheric air are $\frac{28}{36}$ of nitrogen, while only $\frac{8}{36}$ of its weight is oxygen; or, 77 per cent. of nitrogen, and 23 per cent. of oxygen. We must, therefore, furnish five cubic feet of air to get one cubic foot of oxygen; or, by weight, 36 pounds of air to get 8 pounds of oxygen. Besides this, the nitrogen in the air embarrasses the contact of the oxygen with the combustible matter, and it also appropriates a part of the heat created by the chemical combination.

It should also be understood that if the supply of oxygen is insufficient the wrong gas is formed, which, as it is a combination with a less quantity of oxygen, develops less heat, and consequently a great waste of the heating power of the fuel ensues; and, further, that neither oxygen and hydrogen, nor oxygen and carbon, unite readily or in mass, as in that case an open fire would be the best, but only by atoms, or particle by particle. They require time to unite if brought together in large quantities. Oxygen is not the supporter of combustion, as is often said, for a jet of oxygen can be burned in a vessel of hydrogen, as well as hydrogen in a vessel of oxygen. Oxygen is the great destroyer or transformer of

matter, and is kept in check by the nitrogen, from wasting away too rapidly all the substances with which it combines. By the union of pure oxygen gas and hydrogen, platinum can be melted, which cannot be done by any blast of atmospheric air. But oxygen gas is difficult and expensive to manufacture.

As this is an extremely important subject, let us again examine each of these several processes which take place in burning coal, in their order, and more particularly, and give the precise quantities of each required to produce perfect combustion, omitting, however, some unimportant details. This perfect combustion may be defined to be the chemical combination of the hydrogen and carbon in the coal with the largest measure of oxygen with which it is capable of uniting.

When fresh coal is thrown on a fire, the temperature decreases, and if it is under a boiler the steam goes down, because a part of the heat is absorbed in volatilizing or generating the gas from the coal, just as, in the gas-house, a fire is required under the retorts, to separate the gas for illuminating purposes from the coal. This is a very cooling process, and the heat so absorbed, as well as that expended in dispelling the moisture in the coal, may be considered as lost. The amount of loss from hygrometric moisture is given in the chapter on Illinois, page 434. The comparatively small heating power of the highly-bituminous coals, as shown by Johnson's experiments, page 160, is chiefly referable to the loss of heat in evolving the gases, for their theoretical heating power is greater than the semi-bituminous or anthracites, but practically it is much less. As the hydrogen gas is separated, atmospheric air must be admitted, in order that it may be converted into aqueous vapor or steam by the union of the oxygen and hydrogen gas. As you buy your coal by weight, and you know the percentage of hydrogen it contains, we must now learn the proportions by weight of oxygen, and how much air is required. These proportions, chemists say, are one of hydrogen to eight of oxygen, by weight; but, as only $\frac{5}{16}$ of the air by weight is oxygen, we must furnish 36 pounds, or 478½ cubic feet, of air for every pound of hydrogen.'

Next, the carbon must combine with oxygen, so as to form carbonic-acid gas, and these must be, by weight, in the proportion of six of carbon vapor to sixteen of oxygen; and the volume of atmospheric air which contains 16 pounds of oxygen is estimated at 900 cubic feet at ordinary temperature, or 150 cubic feet for each pound of coal.

As the hydrogen separates from the coal, however, it carries with it a portion of the carbon, in the proportion of one-fourth of a pound of hydrogen to three-fourths of a pound of carbon, forming a gas, called carburetted hydrogen, every pound of which requires 18 pounds, or 239¼ cubic feet, of air. This carbon is liberated when the hydrogen and oxygen form steam, and unites with oxygen, if it be present, and forms carbonic acid or carbonic oxide, according to the quantity of oxygen; or, if there be no oxygen, the carbon passes off as smoke. Smoke is not gas, but unconsumed carbon mixed with or carried by steam.

The tables of analysis of coals generally give the percentage of volatile matter they contain, which includes not only the hydrogen, but also a certain amount of oxygen, nitrogen, water, etc. But we may suppose that a good quality of bituminous coal contains five per cent. of hydrogen and eighty per cent. of carbon. In a ton of coal, the 100 pounds of hydrogen will carry off 300 pounds of the carbon, and make 400 pounds, or 10,000 cubic feet, of carburetted hydrogen, and require 7,200 pounds, or 95,700 cubic feet, of atmospheric air. The remaining 1,300 pounds of carbon require 3,466 pounds, or 195,000 cubic feet, of air; or in round numbers the ton of coal requires nearly 300,000 cubic feet of atmospheric air, or 150 cubic feet, for each pound of coal

The heating power of coal may be measured by the quantity of oxygen with which it combines, and not by the quantity of carbon merely, as is often said; and, as hydrogen combines with three times as much oxygen as carbon does, it follows that the heating power of bituminous coal containing hydrogen and carbon is theoretically much greater than anthracite, which is nearly all carbon. We refer here to the intrinsic heating value of the coal; for, in practice, such are the defective methods in use, and so large a portion of the gases is wasted, that the difference in the common mode of burning coal is much less than their composition indicates. The great success of the semi-bituminous coals for steam purposes may, perhaps, be attributed to the fact that they contain such a moderate amount of hydrogen that, while it gives rapidity and intensity to the combustion, yet a larger portion of this important constituent can be utilized with our imperfect methods, and there is less waste of the gases than in the use of bituminous coals containing a larger quantity.

Now let us inquire, What are the consequences if an insufficient supply of oxygen is furnished? The heating power of coal, as was said before, depends on the quantity of oxygen with which it will combine in combustion. Now, oxygen will combine with carbon or hydrogen in certain fixed and definite proportions, and no others. With carbon it will only unite in two proportions in a furnace or fire; forming carbonic-acid gas when it is furnished as before mentioned, in the proportion of 16 of oxygen to six of carbon by weight. If the proportional quantity of oxygen is in the least degree less than that, another gas is formed, called carbonic oxide, which consumes only half the quantity of oxygen that carbonic-acid gas requires. That is, carbonic oxide is formed of these gases, in the proportion of six of carbon to eight of oxygen; and carbonic-acid gas in that of six of carbon to 16 of oxygen. Here the consequence is evident, that but half the heating power of the carbon is developed, unless the whole is obtained. You get the half or the whole. There is no intermediate proportion. But the invisible carbonic-oxide gas is of the same bulk or volume as carbonic acid, and passes off from the fire of a furnace through the chimney, producing no better draft than carbonic-acid gas would have done, giving the impression that all heat has been extracted and made available, while really the fuel is wasted, as truly as

if a certain portion of the coal were thrown out of the window. Distinguished chemists have demonstrated mathematically that the loss of heating power, when carbon is burned to carbonic oxide, and escapes from the chimney in that form, really amounts to 67 per cent. There are, in fact, two distinct operations—one of supplying oxygen to the solid carbon resting on the grate-bars, and the other of supplying it to the gas generated in the upper part of the furnace; and injurious consequences ensue from compelling the whole supply of air to pass through the ash-pit, and through the solid carbon. After the air has entered the fire through the grate, and imparted its oxygen to the carbon and formed carbonic-acid gas, this gas at a high temperature passes on upward through the burning coal, and takes up an additional quantity of carbon, equal to what it had before, making 12 of carbon to 16 of oxygen, or carbonic oxide; instead of six of carbon to 16 of oxygen, or carbonic acid. Thus heat is absorbed, and a portion of the carbon is worse than lost. The common kerosene, or argand lamp gives more light than a candle, because the air in small jets not only comes in contact with its exterior, but is allowed to enter the middle of a circular wick, whereby a greater surface is presented to the air, and more accessible points of contact obtained. This, then, must be done in a furnace, or fire, under a boiler; the air must be introduced in small jets into the body of gas immediately above the fire. They do not mix readily, and they must therefore be brought together in as small quantities or jets as possible, at the surface of the fire, so that as many atoms as possible of each gain access to the other. The whole question of combustion of gaseous fuels turns upon the admission and mixture of air, each atom of which must join its proportion of gas.

In combustion, it seems atmospheric air is, in all cases, the heaviest ingredient. To convert the hydrogen gas into water, oxygen is required, weighing eight times as much as the hydrogen; and, to procure it, atmospheric air is required, weighing 36 times as much as the hydrogen. This, it will be noticed, is more difficult than in the case of the carbon or coke, where the relative proportions are less. To convert the carbon into carbonic acid requires six pounds of carbon to 16 of oxygen, and half that quantity of oxygen to produce carbonic oxide. Every consumer of coal should understand this, not as a curious scientific fact, but as a serious, practical reality, involving dollars and cents. For every pound of coal you buy, you must furnish atmospheric air in the proportions above stated, according to its constituents. That this quantity of air can be introduced through the grate-bars, and through the body of coal upon them, so as to produce perfect combustion, is a physical impossibility. "As well," says Williams, "might you expect air would pass through the lungs of one human being, and yet contain the necessary quantity of oxygen for the support of life in several persons." There is no doubt whatever that the obtaining of the largest measure of heat, from any weight of coal, depends exclusively on the introduction of the air in proper quantity and manner,

inasmuch as neither carbon nor hydrogen is fuel, but only their mixture with oxygen produces heat. With the multiplicity of furnaces, boilers, stoves, and other heating apparatus in use, it would be useless to attempt to give precise forms or dimensions. Every man will indulge his own fancy as to these. All we can do is to lay down general rules and principles.

After arranging for the proper admission of a supply of air in sufficient quantity to produce perfect combustion of the coal, the next question is how to generate the largest amount of heat, and to transmit or apply it so that it may be absorbed, or so applied as to produce the largest volume of steam, or other heating effect. For these purposes, the area of the grate-bars should not be too large, and must at all times be well and uniformly covered. If attention is not paid to preserving a uniform depth of coal and sufficient body of fuel on the bars when the charge is nearly exhausted, or begins to burn in holes, the air passing through the fuel in masses, or streams, a cooling effect is produced injurious to the generation and combustion of the gases. The chamber part of the furnace above the coal, to be occupied by the gases, requires room for their rapidly-enlarging volume, and must not be too small. It should not be simply for the combustible gas to pass through it, but a chamber in which the gases are generated, separated, and brought in contact with the oxygen, and thus combustion effected. In nearly all furnaces, the chamber is made too restricted and too shallow. Flame will not pass through a small flue (Davy's safety-lamp is founded on this principle), and must, therefore, have a sufficient distance to run before it reaches the flue, to consume the gases.

This is an important and almost universal mistake. The constructing of furnace or boiler chambers so shallow, and narrow, appears to have arisen from the idea that the nearer the body to be heated was brought to the source of heat, the greater would be the quantity received. When a bar of iron is to be heated in a forge without regard to the quantity of heat wasted, when time is more important than coal, direct contact is necessary. But, when you desire to obtain all the heat that can be produced by the combustion of all the fuel, absolute contact with flame should be avoided. "This can be easily proved," says Dr. Ure, "by placing a cup containing water over the flame of a candle a little above its apex. The flame continues its brightness and size, and will continue to keep the water boiling. Then lower the cup into the middle of the flame, when the candle will lose its brightness, become dull and smoky, covering the bottom of the cup with soot, and the ebullition will cease from the imperfect combustion." The flame of a candle, or of a coal-fire, is only on the exterior portion of the ascending gas, although it looks like a solid body of flame. All within is unconsumed gas rising in its turn to unite with the oxygen of the air. The heat of a flame depends on its mass. The large bodies of flame in your furnace only burn on the outside, and must have space for all their parts to receive air. If they come in contact with the boiler, or any colder body, it will refrigerate the flame, and prevent that

rapid combustion of the fuel so essential to the maximum production of heat.

The notion, that the gases of coal are consumable by coming in contact with a body of *glowing coals*, is altogether erroneous. Gases may be decomposed, but cannot be consumed by any possible degree of heat. Combustion is their union with oxygen. All the gas is manufactured in every gas-house in a hot retort, but cannot possibly be burnt there until it has access to the oxygen of the air. Mechanical contrivances for introducing the coal into the fire from below will answer to preserve a uniform pressure of steam in a boiler, but they cannot in any way increase the heating power of the fuel.

The introduction of *hot air* does not increase the intensity of combustion. In a blast-furnace, cold air chills the hot iron before the oxygen has united with the carbon of the coal. No more units of heat are evolved, but the combustion is confined to the more immediate vicinity of the tuyères. Hence, the hot-blast is a saving of fuel in that instance. If, however, the oxygen of the air has first united with the coal, the temperature produced would be the same whether the air had been hot or cold; just as powder will explode as well whether it be hot or cold. Air in the gaseous form cannot increase its latent heat. Besides, heated air expands, and contains no more oxygen than when cold, and more of it in volume is required, when heated, to furnish a given quantity of oxygen. Condensed is better than expanded air. This is one reason why a fire burns better on a cold day—because the same quantity contains more oxygen.

Consuming smoke is another error. There can be no such thing. Smoke can be prevented by the proper admission of air, and thus producing perfect combustion; but, when smoke is once produced, it can never be burnt, or converted to heating purposes. Smoke owes its existence to unburnt matter, and, like carbonic oxide, is the product of an imperfect combustion.

It is a very common error to suppose, as the inexperienced are apt to do, that the heat is all obtained and used, and there is no loss of fuel, when no smoke appears to pass from the chimney, as in burning coke or anthracite coal. On the contrary, even in burning coke, or when bituminous coal has been burnt down to a clear, red fire, or in burning anthracite coal, which is nearly all carbon, although the combustion on the grate may appear to be perfect, and little or no red flame be produced, and no smoke whatever made, there may be a great amount of useful heat lost, owing to the formation of carbonic oxide, or carburetted hydrogen, which, not finding a fresh supply of air at the proper place, necessarily passes off unburnt. The volume of flame at the top of rolling-mill chimneys is caused by these unconsumed gases which pass up the chimney, not as a body of flame, but just as they would through a gas-pipe, and burst into flame on reaching the oxygen of the air. Carbonic-oxide gas is invisible, inodorous, tasteless, and therefore gives no evidence of its presence, in passing out of the chimney. It might be added that it is poisonous; in the highest degree injurious to health if allowed to escape in small quan-

tities from the fire in a dwelling, and fatal to life in large quantities. The short blue flame on an anthracite fire is carbonic oxide. Bituminous coal-fires are less dangerous in this respect. Numerous deaths from charcoal fires in close rooms, or from anthracite coal-fires with dampers in the stove-pipes, are caused by this deleterious gas. It is inodorous, and therefore the presence of a little sulphur in the coal alone serves to indicate its presence. Headaches, and other injuries to health, are of frequent occurrence from this insidious, unseen, unknown cause. They are sometimes erroneously attributed to the dryness of the atmosphere, whereas dry air is not injurious, not even that of deserts. But heated iron has no power to abstract moisture from the air. The air becomes hotter, but not drier. Air can hold more water as invisible vapor, as it becomes hotter in the direct ratio of its temperature, but the same air heated contains the same moisture it had before. The injury to health is from inhaling poisonous gases.

Where perfect combustion takes place by the fire being furnished with the proper quantity of air, there will be no soot or smoke produced. Now, it will be observed that the best gas-coals make the most smoke, as is seen at Pittsburg and Cincinnati, where coals are used containing a large amount of gas. The reason of this is, because hydrogen has a greater affinity for oxygen than carbon has, requiring three times as much of it by weight. The hydrogen, therefore, greedily rushes forward, and seizes on all the oxygen that is offered, and even then it often has not enough; while the carbon, being disengaged from the hydrogen, having no share of the limited supply of oxygen, assumes its original, black, solid state, is thrown out as coke with the ashes, the fire being constantly supplied with more hydrogen in fresh coal, or part of it becomes pulverulent, and passes off as smoke and soot.

If too much air is introduced, smoke is also produced. There is a proper temperature required in the gas when the air is introduced, otherwise the union of the oxygen of the air will not take place, and smoke will be formed. The dark-yellow vapor, rising from heated coal when fresh coal is put on a fire, however, is caused by sulphur, or earthy impurities in the coal. The appearance or non-appearance of visible smoke is, therefore, no test of the perfect combustion of coal. On the contrary, quite a large volume of black smoke may indicate the loss of a comparatively small quantity of fuel. Smoke is unconsumed carbon, it is true; but, as we know that a few drops of ink will blacken many gallons of water, so much more the steam or white aqueous vapor, which must pass from every chimney burning coal that contains any hydrogen gas, can be easily blackened by a very small quantity of carbon. A ton of bituminous coal properly burnt produces half a ton of water, which passes off as steam; an enormous volume, which a very little carbon will blacken into smoke.

In the Report of the Royal Commission, appointed to inquire into the subject of coal in England, it is stated that the highest practical result which has been realized, in burning coal, is less than one-eighth of the

theoretical value of coal, and this without counting the impurities of ordinary coal, which cannot be taken at less than 10 per cent. The theoretic effect of a pound of coal is to lift 10,800,000 pounds one foot high. In practice, the same weight of coal, applied in the best engines, raises 1,100,000 pounds one foot. The very highest practical result which has been attained is 1,800,000, or under one-eighth, without counting the impurities in the coal. There are two sources of loss: first, in generating the steam or in burning the fuel, which is done at a disadvantage where practically a pound of fuel does not evaporate more than seven pounds of water, whereas the theoretic duty ought to be about 13 pounds; the second loss of heat is in the condenser, which throws off an amount of heat which might be developed to a great extent in producing force by expansion. But, if we take all sorts of steam-engines, the actual realized effect of the coal would be about one-third of that stated above, or about one-thirtieth of the whole theoretic value of coal. The chief loss in a high-temperature furnace is through the serviceable heat carried away by the chimney; another important loss is through the unconsumed gases, a third through uncombined oxygen, and a fourth through radiation.

The greatest improvements made in modern times in the several methods of manufacturing iron consist in the greater economy in fuel; one of the best of these is the improved heating-furnaces of C. W. Siemens, of England. These regenerative furnaces consist of three parts. The first of these parts is the gas-producer, or apparatus for converting the solid fuel bodily into a gaseous fuel. Secondly, the apparatus consists of the regenerators or sunk chambers filled with fire-brick, piled in such a manner that a current of air or gas passing through them is broken into a great number of parts, and is checked at every step by the interposition of an additional surface of fire-brick. Four such chambers are placed below the furnace, and the currents of gas and air can be directed by suitable reversing valves either upward or downward through these chambers. The third essential part of the arrangement is the heated chamber, or furnace proper, in which the work is intended to be accomplished, which communicates with two of these generative chambers, and, in directing currents of gas and air through the latter, the two gaseous streams meet on entering the heated chamber where they are ignited. The current then passes out through the two remaining regenerators, and heats them in such a manner that their checker-work of fire-brick is heated to nearly the temperature of the furnace, whereas those from which the current comes are becoming less and less heated, and the products of combustion, being absorbed in the receiving-chamber, escape into the chimney comparatively cool. In the course of, say, an hour, the currents are reversed, and the air and gases, by closing and opening the valves, are caused to pass through the two chambers which had just been heated, take up the heat there deposited, and pass into the furnace proper where the work is to be done, and pass out into the other two chambers, which have now in turn become the receiving-chambers to be heated.

By this process, twelve hundred-weight of ordinary coal suffices to melt a ton of steel; whereas, in the ordinary furnace at Sheffield, about three tons of Durham coke are necessary to accomplish the same end. In the manufacture of iron and other work, better results in every respect are attained, but the comparative economy is less than where very high temperatures are required.

Thomas Russel Crampton testified before the Royal Commission as to an improved method he had contrived for producing perfect combustion of coal by discharging it in a powdered condition into the fire by a current of air. The ordinary condition of burning fuel is the evolving of first the hydrogen, and afterward the carbon or coke, and mixing them intimately with a given quantity of oxygen from the atmospheric air. To obtain perfect combustion, time is required, or the gases must be intimately mixed. In doing this in the ordinary way on a grate, the air passing through the bars takes its chances of being mixed; the process is uncertain and irregular. You cannot, in feeding a fire, arrange the interstices of the fuel perfectly even, the bars cannot be regularly covered, and the result is that, with a given space in the chamber, gases are evolved at different rates, since the interstices in the fuel vary considerably. You have sometimes not sufficient air passing through the interstices, and at other times it passes through unconsumed. Too much oxygen entering the utilizing chamber injures the iron you are heating or welding, besides causing a waste of fuel.

The machinery used for burning pulverized coal is merely an ordinary fan-blower. The air is blown into a small brick chamber previously heated, the fine coal being dropped into the stream of air by a little inexpensive apparatus, which regulates the quantity required simply by turning two handles, which introduces any quantity of both air and fine coal. By looking into the furnace the state of the flame can be seen and regulated at will, and any quality and quantity of flame desired can be obtained without a particle of smoke. The jet of air and fine coal enters the furnace in a state of cloud, striking on all sides, causing great agitation of both, and the gases from the coal are thus readily mixed as they are evolved. The result is, that you have as perfect a flame as can be conceived.

All particles of coal larger than an impalpable powder will necessarily require time for consuming them, according to their size. If you were to take a cubic foot of solid coal, and put it into a furnace and float it, if it were possible to do so, for a mile, with air in contact, it would not be consumed; even a particle no larger than a pin's-head would not all be consumed within the limits of an ordinary furnace. If you could take fuel and reduce it to an impalpable powder, such as we can imagine soot to be, and mix that with air with a given amount of heat, it would be consumed very nearly as rapidly as gas is. The larger the coal, therefore, the greater the distance it should enter the furnace from the work. The chemical constituents of the coal, as to the proportions of carbon and

hydrogen it may contain, would be an important fact in regulating the dimensions of the combustion-chamber to be used. Anthracite-dust, of which such mountains in quantity are now wasted, would require a greater distance than bituminous coal, but this will possibly prove to be the best mode of utilizing it. Mr. Crampton claimed that in five and a half hours work was done in puddling and heating by this process which required twelve hours to do by the ordinary methods, and with a saving of thirty per cent. of the coal, or using nineteen and a half hundred-weight to thirty hundred-weight before, with the same description and size of furnace, with the same men, and with the slack or fine of the same coal. The ashes or earthy matter in the coal runs out, in a liquid state, from a hole in the bottom of the chamber. It does not matter how dirty the coal is, the whole of the heating power of the coal is utilized, the only difference being in the quantity of slag.

Besides, in an ordinary furnace, both time and heat are lost in opening the furnace-doors, and in putting on fresh coal. In these furnaces no such losses occur, as no cooling from the admission of cold air takes place.

In localities where good coal is scarce and expensive, all plans like the foregoing, founded on sound principles, are worthy of consideration and trial. All good mechanical contrivances for using inferior fuel or developing its heating power are important.

Dr. William Fairbairn testified before the Commission that the amount of fuel consumed now (1869) in the smelting of ore is about two and a half tons of coal to a ton of iron, and that about three tons more are used in the whole of the subsequent processes, such as the puddling, rolling, and every process connected with the conversion of iron into steel. The consumption of coal in the English iron-manufactories alone is something like 32,000,000 tons per annum. Very great economy has been effected in the use of coal of late years. More than double the quantity of fuel was consumed formerly, before the introduction of the hot-blast, in proportion to the quantity of iron produced, as compared to what is consumed at the present day. By utilizing the gases, and other improvements, still greater economy may be effected. By the application of the hot-blast, the same amount of fuel reduces three times as much iron, and the same amount of blast does twice as much work as previously.

In America, from 1¼ to 2 tons of anthracite coal is used to smelt a gross ton of pig-iron from the ore; or of Pennsylvania and Ohio bituminous block-coal two tons, and of Indiana block-coal two and a half tons; or of Connelsville coke, 70 to 85 bushels made from 2 to 2½ gross tons of coal.

The quantity of bituminous coal required in puddling, or converting pig into wrought iron, is as follows: Of Pittsburg coal, 2½ to 3 tons, according to the size of iron made; but, with semi-bituminous coal, one net ton will puddle a ton of iron, and for reheating or muck-heating, a half ton more, making 1½ ton to a ton of iron of ordinary sizes.

In melting pig-iron for foundry purposes, from 350 to 400 pounds of the best Lehigh coal are used, to 2;240 pounds of pig. The larger the

quantity melted, the less coal is used per ton. At Pittsburg, one pound of coke is used to four pounds of iron melted.

If space allowed, many other questions in regard to the combustion of coal, the economy of fuel, and the transmission and useful application of heat, might be discussed; such as draught, grate-bars, the forms and construction of boilers and furnaces, quick and slow combustion with reference to the time employed, thick and thin beds of coal, etc.; but this would lead us into details inconsistent with the plan of this chapter, which was merely to point out the most prominent defects in our present methods of burning coal. We have no patent improvement to sell, no favorite plan of construction of stoves or furnaces to offer. In this country every man is his own architect and his own engineer. As he will build his dwelling to suit his own taste and fancy, so he will construct or choose his apparatus to heat his house or factory, to generate steam for his power, or other heating purpose, just as he thinks proper, without submitting either to the dictation or even the instruction of any one. All that can be done is, to instil into the public mind sound scientific principles, in the hope that they may, hereafter, bring forth fruit in improved methods of burning coal, founded on an intelligent knowledge of the conditions which the investigations of modern science show to be necessary for its complete combustion. The use of fire distinguishes man from the brute, and lies at the foundation of civilization, and the material civilization of a nation may be measured by the quantity of coal it consumes in proportion to its population, allowing for the difference of climate. But our present rude and barbarous methods of applying and developing this great power which Nature has placed in our hands are the same which were practised in a period of comparative darkness in the natural sciences, and form a conspicuous example of the wastefulness so characteristic of our times and our people.

V.

IRON-ORES OF THE COAL-REGIONS.

A SINGLE volume cannot contain a suitable account of all the mineral wealth of the United States. This work is intended to be confined to coal, or, more properly, the coal-regions; for there are some very important branches connected with the general subject of coal, such as mining, mining-machinery, and mining-life, which are here omitted. Great as is the quantity of the mineral productions of the coal-districts, their number or variety is very small, consisting chiefly of coal and iron. A brief account of the iron-ores of the coal-measures is not only appropriate, but it seems to be necessary in giving an account of the coal-regions, especially as very little is known in regard to them, even by those engaged in the various branches of the coal business.

Pennsylvania is often spoken of as containing inexhaustible stores of coal and iron. This is only true as to her coal; for her stock of iron-ore, both as to quantity and variety, is not to be compared with that of a number of the other States, although she produces more than any of them. She is a great manufacturer of iron, and her thrifty and industrious people make good use of the iron-ores they find at home, but the greatest deposits of iron-ore are outside of her borders, except the brown hematite of the Cumberland Valley from Easton to the Maryland line, south of Chambersburg. A knowledge of the principles of geology is necessary in searching for coal; and it is certainly equally important in regard to iron-ore, which all experience and observation prove is not distributed fortuitously, but is only to be found, in valuable quality and quantity, in certain geological formations.

For practical purposes, our iron-ores may be divided into five classes: the primary, the hematite, the fossil, the carbonates, and the bog-ores; and, as a general statement, it might be added that this is also their order in the geological formations, each occupying a great belt of country parallel to the Atlantic coast, and succeeding each other in going from east to west, except the bog-ore, which is mainly deposited in the newer formations nearest the coast. Its name indicates its character, it may occur in any formation, and is sometimes found in the coal-measures:

1. The lowest in the geological scale, the largest in quantity, and the

most important, are the primary, specular, magnetic, and red oxide iron-ores, found below all the fossiliferous rocks of the country. No fossils of either animals or vegetables are found in them, and, like the rocks among which they occur, they are metamorphosed and changed. Our primary country (*see* Azoic, or No. 1, on Geological Sketch of United States, page 2) extends from Maine westward, through Canada, to and south of Lake Superior, it covers the Adirondack country in Northeastern New York, and it stretches from New York City across New Jersey and the southeastern part of Pennsylvania; it is the Blue Ridge of Virginia, covers Western North Carolina, and terminates in Georgia and Alabama. This is the region for magnetic or primary iron-ores. Near Port Henry, for example, on the west bank of Lake Champlain, are immense bodies of primary ores, not in veins of the ordinary form and size, but in great masses, which have in some instances been quarried out in the open air for 300 feet long, 100 feet wide, and 200 feet deep, without proving the thickness of the deposit. New Jersey also possesses great deposits of primary ores, and from these mines large quantities are carried into Pennsylvania, "where the magnetic ores dwindle to a shadow." Virginia and North Carolina are also richly endowed with the same kind of iron-ore, as well as South Carolina, Tennessee, and Georgia.

The celebrated Iron Mountain, 75 miles southwest of St. Louis, covers 500 acres, and is 228 feet high, the ore yielding 55 to 60 per cent. in the blast-furnace, of very superior iron. Pilot Knob, six miles farther south, has its summit, measuring two acres, composed of pure iron-ore requiring no selecting or washing. These were little islands of the primary age, but they are surpassed by the Lake Superior region, where this species of ore, a red oxide, is found in unheard-of quantities, covering a great extent of country, of an excellent quality, and with the great advantage of a very cheap water transportation on the chain of great lakes, by which it is readily transported to the States extending along its southern borders for more than 1,000 miles. The annual production is now nearly 1,000,000 tons.

2. In ascending the geological scale, we next meet with the brown hematite ore which occurs in the Trenton limestone (No. 2, or Silurian, on the geological sketch, on page 2), the second of the fossiliferous rocks (the first being the Potsdam sandstone), forming the great valley extending from Canada to Alabama, and known as the Kittatinny or Cumberland Valley, in Pennsylvania, the Valley of Virginia, and the Valley of East Tennessee. This ore is found in the soil, and resting on the limestone occupying hollows or basins in the surface of the rock, in thousands of localities throughout the extensive belt of country mentioned. The quantity of this brown hematite ore in Cumberland Valley, in Pennsylvania, "attainable by proper mining operations, has no assignable limit, and will furnish supplies for centuries."

3. The third geological region, where valuable iron-ore is found, is in the Clinton group, also No. 2 or Silurian, V. of the Pennsylvania forma-

tions (*see* list on page 115), which produces what is called the fossil ore. The Clinton group is coextensive with that last described, but the iron-ore is not only of very uncertain thickness, but often does not show itself at all. It extends through New York State from east to west, and is the valuable iron-ore of Montour's ridge at Danville, Pennsylvania, also at Holidaysburg in the same State, and in the Broad Top region. Running parallel to the Alleghany Mountain, it is found in East Tennessee, and in very large quantities in Alabama. The great faults or upthrows of the country have brought up the iron-ore in the vicinity of and on a level with the coal-field, and it is said to be there 20 feet thick. The Clinton ore is found in Muskingum County, Ohio, in Dodge County, Wisconsin, and many other localities.

4. The foregoing iron-ores are all oxides, while those remaining to be noticed are carbonates, the first being in the black slate of the Marcellus shales; but, compared with the others, this is neither rich nor productive.

We must now pass over immense geological formations, wholly destitute of valuable iron-ore, meeting with none until we get up to the last layers of red shale immediately below the conglomerate, which forms the base of the coal, and more strictly applicable to our subject. Indeed, if we examine a geological map of the United States, and consider for a moment the great thickness of the formations, the very small size of the beds of iron-ore, and their uncertain and deceptive character, we shall conclude that this most useful of metals, although there is enough of it for human wants, is not so widely distributed as we are accustomed to think. There are vast regions of our country large enough for many States, which do not contain any iron-ore whatever of commercial value.

The Catskill group has been divided, by the stratigraphical geologists of Pennsylvania, into three formations: IX., or Rogers's Ponent; X., Vespertine; and XI., Umbral, or two red shales separated by a coarse sandstone, or in the anthracite regions by a conglomerate. The last or uppermost of these is a very soft red shale 3,000 feet thick at the anthracite country, but thinning out toward the Alleghany Mountain. In the Towanda, McIntyre, and Blossburg regions, it is divided into two parts by from 50 to 200 feet of greenish sandstones. The ore of the Umbral, or XI., has been opened at Blossburg in several layers within 100 feet below coal A, and 180 feet below the conglomerate. At McIntyre it has been opened on the same horizons as at Blossburg. The same ore has been opened, says Mr. Lesley, in a hundred places along the anticlinals of the first four coal-basins, whenever they bring up the conglomerate and the red shale of XI. But nowhere has it been used for furnaces until we approach the Maryland and Virginia line, as at Dunbar Furnace, in Fayette County.

Ascending now to the coal-measures proper above the great conglomerate, commonly assumed as the basis of that system, the iron-ores which are of value for the manufacture of iron are chiefly confined to the lower coal-measures, and therefore appear around the shallower parts of the basins or areas. Having perused the details of the description of

41

the several coal-fields of the United States, the reader, by being informed of the geological level of the iron-ores, will be able to see where it must crop out around the borders of the coal-regions. Although, in the sections given, many layers of iron-ore are mentioned, most of them are of no value for iron-manufacturing purposes. There is in all our coal-measures "but one layer, the buhrstone-ore, which surpasses in importance, and is in fact the chief occasion of the erection of the numerous iron-works, which occupy a belt around the margin of the coal-measures, and based on their iron-ores." It is always situated between coal-beds B and C, about midway between them, say 30 feet above the former and 25 feet below the latter. In order to define the place of this bed in the series, Mr. J. P. Lesley, in his "Iron Manufacturer's Guide," the best work extant on the geology of the American iron-ores, gives the following approximate section of the lower coal-measures. "They form," says he, "a system by themselves, included between the triple conglomerate at the base and the triple Mahoning sandstone 400 feet above it."

Section of Lower Coal-Measures, showing Position of the Iron-Ore.

	Feet.
19. Mahoning sandstone in three divisions in all	75
18. Shales	50
17. *Coal E*, the Upper Freeport, sometimes over	6
16. Limestone e	8
15. Shales	50
14. *Coal D*, the Lower Freeport, over	3
13. Sandstone, with thin coal	70
12. Shales, with thin coal-beds	100
11. *Coal C*, the Kittanning (cannel), seldom	4
10. Shales, sandy and clayey	25
9. ORE AND BUHRSTONE, average ½ from 1 to	10
8. Limestone (encrinal), greatest thickness	23
7. Shale, sandy, over	30
6. *Coal B*, less than	4
5. Shales, with thin coal-seams	40
4. *Coal A*, always thin	2
3. Conglomerate sandstone	15
2. Shale, sandy	50
1. Conglomerate sandstone	30

"The proportions vary frequently, as we might expect, and rapidly from mile to mile, but so constant and on so grand a scale were the agencies which formed the members of the system, so steady were the oscillating movements of the continent, and so continental the expanse of watery marsh and penetrating sediments, that the main features of the section, as a whole, suffer but little change as we pass eastward toward the anthracite, or soutwestward toward the Kentucky fields. The top rock is the Mahoning sandstone, everywhere on Broad Top, in the Cumberland, the Somerset, Ligonier, and Monongahela basins, and in Southern Ohio. The

interval indeed, on Broad Top, is but about 200 feet, and in Somerset 400 feet, but the two principal coal-beds lie always, the one, B, near its bottom, and the other, E, near its top; the ore maintains its status at Johnstown on the Conemaugh, as at Hanging Rock on the Ohio, and the very fossil shells, leaves, fruits, and stems of trees, preserve throughout their several and separate stages, and mark the separate beds." At Johnstown the buhrstone-ore is found in its proper place, but the iron-ore so extensively wrought for the iron-works overlies the highest workable coal-bed E about 60 feet, and the water of the river about 250 feet. The upper ore is in two benches, the one 1½ to 2½, and the lower one ½ to 3 feet thick, and they are separated by a thin seam of clay. By analysis they yield 51 to 52 per cent. of iron. The two benches thicken and thin alternately, keeping the whole thickness about the same. The furnaces run on coke, and often need no limestone-flux.

The Barren Measures, between the Mahoning sandstone and the Pittsburg seam, as well as the upper coal measures and the upper Barren Measures, by which the whole system is crowned in Southwestern Pennsylvania, are wholly destitute of valuable iron-ore beds.

The following account of the characteristics of the beds of iron-ore in the coal-measures is also by Prof. J. P. Lesley, and is taken from his *United States Railroad and Mining Register*. It is of course only applicable to the first or Alleghany coal-field, as the formation of the Michigan, Illinois, and Missouri, or three Western coal-fields, is different, and no workable iron-ores are found there. The Lake Superior iron-ores are used in the furnaces of Indiana and Northern Illinois. It should also be mentioned that no valuable iron-ores are found in the Pennsylvania anthracite regions.

"The iron-ores of the coal-measures form a class by themselves. The English name for them, clay-iron-stone, very well expresses their character. They are, in fact, beds of hardened mud charged with iron. The clay consists of sand and clay (silica and alumina), not combined in any fixed proportions. The iron is in the form of carbonate of iron, a mixture of iron, carbon, and oxygen. The original sedimentary mud received also various other contributions, such as potash, soda, lime, magnesia, sulphur, and phosphorus. Some of these floated in from the felspathic rocks of the river-valleys. Others came from decomposing land vegetation, sea-weeds, or animal organisms. Some was chemically formed from solutions in the water. The lime exists in the stone, as does the iron, in the form of a carbonate, showing the influence of organic carbon.

"As a general rule, where clay-iron-stone is rich in carbonate of iron, it is deficient in carbonate of lime. On the other hand, a bed of this kind of ore will ofttimes pass into a bed of clayey limestone, or sandy limestone, in the short distance of a few hundred yards, showing under what a great variety of conditions the mud was deposited in the broad waters of the Coal Era. Streaks, or belts, of rich iron-mud, will run through the hills of a district, and fine off to nothing on each side, the iron disappearing

from the rock, or being replaced by lime. No furnace ought to be erected, therefore, anywhere in our coal-measures, until the whole surrounding district has been carefully and thoroughly examined. For, no matter how thick the bed of ore may be where it emerges from the hill-side, at any one point, it may thin away to nothing when mined into a few hundred, or even but a score of yards. Many a furnace has been erected near a deposit of iron-ore in the coal-measures supposed to be inexhaustible, but has been abandoned in six months, or in a year or two, because the ore had vanished from the gangways of the mine.

"In this respect, the coal-measure clay-iron-stone differs essentially from other classes of iron-ores, like the Lower Silurian brown hematites of the limestone valleys, or the magnetic and red hematite ores of the primary mountains. These occur, indeed, in very irregular masses, but in masses of enormous size, occupying a small space, but containing so many hundreds of thousands, or millions of tons of rich ore as to be actually inexhaustible by ordinary works.

"The same is true of the fossil iron-ore of No. V., although that lies in a thin stratum, like the clay-iron-stone beds of the coal-measures. It is continuous for miles. It is, therefore, a reliable deposit. Wherever it is found thick at any one point, it may be trusted to continue so throughout an extensive property.

"In regard to quantity of contained iron, the coal-measure clay-iron-stone is inferior to the others above named. The percentage of clay and sand in it is always great. The presence of carbonate of lime, etc., still further diminishes the percentage of iron. Finally, the iron, instead of being allied only with oxygen, is allied with carbonic acid—carbon as well as oxygen.

"Consequently, no coal-measure iron-ore bed ever yields much more than 40 per cent. of pure iron. All the rest must pass the furnace-dam as cinder or waste. The fossil-ore and the brown hematite yield 50 per cent.; the magnetic and red hematite yield over 60 per cent. of pure iron. These rich ores are, therefore, brought from great distances to the furnaces situated in the coal-region, to be mixed with, and to increase the yield of the clay-iron-stone stock. Hence, the great iron-works of the coal-region must be on great lines of railroads.

"Most of the beds of clay-iron-stone in the coal-measures are merely beds of shale, holding *balls* of a sandy or clayey carbonate of iron. We often hear of beds of this ore, 10, 20, or 30 feet thick. But, when such places are visited by an expert, they are found to be worthless; they are merely piles of clay and sand deposits, throughout which, from top to bottom, are to be seen sticking out round nuts, knobs, and bowlders of clay-iron-stone. If the balls could be got together in one large layer, and that layer were only two feet thick, they would make a very nice bed of ore; and profitable mining could be done on it, and a furnace, or half a dozen furnaces be erected safely in the vicinity. But, as it is, no method of mining known to man could get out enough of these balls to run a

furnace, except at an expense greater than that of bringing ore from Lake Superior, or Missouri.

"Even where the clay-iron-stone lies in a solid plate, it usually breaks up into balls, when followed into the body, or along the side of the hill; and mining then becomes unprofitable. The only condition under which such balls, or thin beds of this ore, can be successfully worked, is where they immediately overlie or underlie a coal-bed so as to allow the profits of the coal-mining to pay for the mining of the ore; or when the only expense attending the gathering of the ore is that of picking the balls and slabs of ore from the *débris* of the coal-mine.

"From all that has been said above, it may easily be gathered that the quantity of *practically accessible and useful* iron-ore in the bituminous coal-measures of Pennsylvania, and the neighboring States, is far less than people imagine. In fact, the map of the great coal-region is dotted over with abandoned furnaces, and millions of dollars have been thrown away on these fair-looking, seductive, but treacherous deposits.

"Nevertheless, the clay-iron-stone of the coal-measures is one of the most valuable of all the iron-ores; and those properties which are in possession of the exceptionally good exhibitions of this kind of ore can hardly be said to have a money valuation. The reasons for this are threefold: First, from the rarity of such properties, it is so seldom that a bed of coal-measure ore both thick and continuous is to be seen. Secondly, from the situation of such a property; for its hills, containing ore, cannot fail to contain beds of good coal and limestone also; so that a furnace will find flux, fuel, and burden, together almost at its tunnel-head. Thirdly, from the peculiar nature of this class of ores, they are the easiest of all to smelt. The carbonic-acid gas flies off, and leaves a cellular mass under the influence of the reducing agents in the furnace. Sometimes the quantity of carbonate of lime is so great that the ore has a perfect flux in itself; melting down into a glass of the double silicate of lime and alumina, and letting the iron drop into the hearth like so much melted butter.

"For these reasons the coal-measure ore-beds will always be greatly sought after. But there is still another good point to be stated. The action of the oxygen of the moist atmosphere on such an ore is a slow but sure combustion. It has been going on through countless ages. It has converted the outcrops into a still better sort of ore. It has done slowly what the heat of the upper part of a blast-furnace does rapidly—drive off the carbonic acid, or rather burn out the carbon, and leave the iron simply oxidized. The whole face of a hill shows this action. The Clarion County ore deposit is merely the mouldered outcrop of iron-bearing shales reduced to the condition of an ore-bearing clay.

"But the same effect is produced far under the body of a hill, by drainage-waters carrying air. The water follows the joints which split up the solid ore-stratum into cakes, or tablets, from one to three feet square. The water acts on the faces of these joints, converting the iron carbonate into an iron oxide, to a depth of half an inch or so, on each

side of each joint. When there are two or three layers of the ore, the water has got between them, and made intermediate layers of oxide (hydrated sesquioxide) of iron.

"Consequently, the miners find the carbonate ore already separated into blocks to be roasted and broken up fine for the furnace; and they also find a certain quantity of ore roasted for them by Nature, fifty per cent. ore, destitute of lime, and serving to rectify the overabundance of lime in the carbonate ore. Nature ought to have taken out a patent for so admirable an arrangement.

"The facts above stated are acquiring a greater importance from the rapid extension of the railroad system in the country lying between the Ohio waters and the seaboard. The multiplication of branch roads attached to the Philadelphia & Erie, the Pennsylvania Central, the Alleghany Valley, the Baltimore, Connellsville & Pittsburg, and the Baltimore & Ohio Railways, is opening up a large field of inquiry into the best localities for iron-works planted on coal-measure ores. The old ore-banks are being reëxamined, and newly-discovered outcrops are exciting universal interest. Large sums of money are being invested in coal-iron properties; and the railway companies are finding themselves drawn into the purchase of the best sites, by a wise foresight of their own future necessities.

"However numerous private furnaces and forges may be, there are but a few prime natural centres of iron-manufacture; and upon these the great railways must always place their chief dependence. What the Cambria Works at Johnstown are, with its dozen blast-furnaces, its vast rolling-mill, and incipient Bessemer steel-works, to the Pennsylvania Central Railroad, such will soon be some great establishment on the Connellsville road so soon as the ores of the Youghiogheny Valley come to be well enough known to determine the proper point; and such, for the Baltimore & Ohio Railway, will probably be the fine deposit at Irondale, near Grafton. So much speculative rumor is afloat, that the public mind is bewildered and unsettled about the first principles of mineralogy and geology; and we think we cannot do the railway interest a greater service than by stating and restating such geographical and geological facts as bear directly and powerfully upon that first and greatest desideratum, the actual quantities and precise localities of the raw material of the iron-manufacture."

VI.

STATISTICS OF COAL MINED.

I. IN FOREIGN COUNTRIES.

A comparison of our trade with that of our neighbors is always instructive. The largest production of coal in the world is that of Great Britain, which is more than three times that of the United States, and more than all other countries in Europe together. A brief account of it may be useful, now that it is supposed to have attained its maximum, while ours has scarcely passed its infancy.

The following are the official statistics of the coal mined in the United Kingdom of Great Britain:

YEARS.	Tons mined.	Annual Increase.	Annual Decrease.	Home Consumpt'n	Tons exported.
1854	64,661,401	....	....	60,351,146	4
1855	64,453,070	....	208,329	59,476,168	4
1856	66,645,450	2,192,371	....	60,755,671	5
1857	65,394,707	....	1,250,743	58,656,969	6
1858	65,008,649	....	386,058	58,479,166	6
1859	71,979,765	6,971,116	....	64,972,815	7
1860	84,042,698	6,062,933	....	76,720,586	7
1861	86,039,214	1,996,516	....	78,184,099	7
1862	81,638,338	....	4,400,876	73,336,496	8
1863	86,292,215	4,653,877	....	78,017,003	8
1864	92,787,873	6,495,658	....	83,977,965	8
1865	98,150,587	5,362,714	....	88,960,110	9
1866	101,630,544	3,479,957	....	91,676,693	9
1867	104,500,480	2,869,936	....	94,084,702	10
1868	103,141,157	....	1,359,323	93,316,353	10
1869	107,427,557	4,286,400	....	96,889,182	10
1870	110,431,192	3,003,635	....	99,926,990	11
1871	117,352,028	6,920,836	....	104,809,162	12
1872	123,497,316	6,145,288	....	110,365,355	13

It is remarkable that there is no authentic account of the quantity of coal mined in Great Britain previous to the year 1854. The first report of the "Mineral Statistics of the United Kingdom," giving with all possible exactness the quantity of coal raised, as obtained by direct application to the coal-owners, was published in July, 1855, and annually since that period a similar detailed report has been issued. The following is an estimate, made from the best data obtainable, by Mr. Robert Hunt, the chief of the Mining Record Office, of the United Kingdom, of all the coal mined in Great Britain since coal was first used in the country:

Mined in the three centuries before 1800	850,000,000
Mined from 1800 to 1853	2,000,000,000
Mined from 1854 to 1870	1,454,224,897
Total coal mined in Great Britain	4,304,224,897

The following are the uses made of the coal mined in 1869:

Used in iron manufactures	32,446,605
General manufacturing, steam-power, etc.	25,327,213
Metallurgies, other than iron	859,231
Mines and collieries	7,225,423
Gas and water-works	7,811,980
Steamships	3,277,562
On railways	2,027,500
Domestic consumption	18,481,527
Miscellaneous	195,045
Exported	9,775,470
Total production in 1869	107,427,557

Among the notable points in the above statement are the very large proportion of the coal used in the manufacture of iron, thirty-two and a half million tons, and the small quantity used on railroads, being only two million tons. In looking forward to our probable future coal-trade, it is evident that our railroads will soon furnish a large, perhaps the largest item in the account of our consumption of coal, instead of one of the smallest, as in England. The use of wood in locomotive-engines is only temporary. So large is the consumption of fuel in these machines, that our forests go down before them. On the New York Central Hudson River Railroad, each engine consumes seven hundred and fifty tons of coal per annum. On roads with a lighter traffic, a less quantity may be used, but it cannot be questioned that the consumption of coal in this manner will very soon amount to many million tons. The use of coal for domestic purposes in this country will very much exceed that of Great Britain in proportion to the population, owing both to the greater severity of the climate, and the more equal distribution of property, which enables our whole people to indulge in the free use of the best fuel. The manufacture of iron is vastly on the increase here, as well as manufacturing generally, both of which have been lately much stimulated by the increased price of coal, and cost of labor of all kinds, in England.

The exportation of coal is a branch of the trade which has scarcely begun in America, and which is destined at an early day to absorb millions of tons of our production. Our beautiful anthracite, the finest domestic fuel in the world, only needs to be known and used, to become one of the luxuries which the wealthy abroad will require of Pennsylvania.

There is the same gradation in the coal-fields of Great Britain as in Pennsylvania (see pp. 108–111). The type of perfection in gas-coal is the Scotch Cannel. The quantity of gas produced decreases constantly in going southward, through the Lancashire, Yorkshire, Newcastle, and Staffordshire basins successively. Farther south than the last, the coals run through several varieties of semi-bituminous into the anthracite of South Wales and Ireland, and then into the worthless culm of Devonshire. It is estimated that there are in Great Britain seventy varieties of coal.

MINING IN THE THICK COAL AT DUDLEY, S. STAFFORDSHIRE, ENGLAND.

Names of the Coal-Basins as numbered on the Annexed Maps.

No.	LOCALITY AND DESCRIPTION.	Sq. Miles.
1....	Devonshire—Anthracite	1,110
2...	Bristol—Numerous thin seams	200
3....	Forest of Dean—Excellent coal	45
4....	Newent—Coal disturbed.......	2¼
5...	Worcestershire — Wyre, Bewdley, etc.............	67
6....	S. Shropshire — Tillerston Clee Hill.................	8
7....	Shropshire—Brown Clee Hill..	2
8....	Worcestershire—Licking Hill.	1
9....	Warwickshire—30 feet coal...	60
10....	Leicestershire—Ashby de la Zouch	62¼
11....	S. Staffordshire—Dudley......	100
12....	Shropshire—Coalbrook Dale..	32
13....	Shropshire—Shrewsbury......	25
14....	N. Staffordshire—The Potteries......................	68
15....	N. Staffordshire—Cheadle.....	15
16, 17.	Derbyshire—Darley Moor & Shirley Moor............	2
18....	Lancashire and Cheshire—Great Manchester Basin..	600
19....	Yorkshire—Kirby Lonsdale...	4
20....	S. Yorkshire, Derby, and Nottingham—Great Central Basin.................	1,010
21....	Yorkshire and Lancashire..	750
	Millstone Grit Range........	250
22....	Westmoreland—Appleby......	26
23....	Cumberland—Whitehaven, etc.	120
24....	Yorkshire—Poor Lignite......	150
25....	Durham and Northumberland, or Newcastle—The most important of all.....	780
26....	Durham and Berwick.........	20
27....	Northumberland..............	580
	Total, England...........	6,089
	SCOTLAND.	
27....	Dumfriesshire	......
28....	Lanarkshire	......
29....	Clyde.........................	......
30....	Johnstone.....................	......
31....	Midlothian....................	......
	SCOTLAND (*continued*).	
32....	E. Lothian....................	......
33....	Kilmarnock....................	......
34....	S. W. Ayreshire..............	......
35....	Fifeshire......................	......
36....	Brown lignite.................	......
	Total, Scotland...........	1,720
	NORTH WALES.	
37....	Isle of Anglesea..............	18
38....	Menai Straits.................	7
39....	Flintshire	185
	SOUTH WALES.	
40....	Glamorganshire	950
	Total, Wales.............	1,160
	IRELAND (*Bituminous*).	
41....	Antrim, or Bally Castle.......	250
42....	Dungannon, or Tyrone........	250
43....	Area west of this............	15
44....	Monaghan	200
45....	Cavan.........................	15
46....	Leitrim.......................	300
	Anthracite.	
47....	Carlow, Queens County.......	240
48....	Kilkenny	20
49....	Tipperary	150
50....	Clare.........................	500
51....	Limerick......................	1,000
	Lignite in Antrim............	......
	Total, Ireland.............	2,940
	Total, England................	6,089
	Total, Scotland...............	1,720
	Total, Wales..................	1,160
	Total, Ireland................	2,940
	Total square miles........	11,859

The most important and productive of the coal-fields of England is the Durham and Northumberland basin near Newcastle (No. 25 on the map). It is 50 miles long, from six to 24 miles wide, and produces about 24 per cent. of the coal mined in England. In this basin are 16 seams of coal more than 18 inches thick, six of them being more than three feet, and ten of them less than three feet. The two most important beds, the High Main and the Low Main, are each of a thickness of six feet, with a layer of slate or poor coal in each. In England, six feet in thickness of coal is a good bed, and from one to two yards is a common size. This north-of-England region has been for a long time the principal source of the supply of English coal.

The Staffordshire and Worcestershire coal-field is 21 miles long, and its mean breadth is between seven and eight miles. The Dudley coal, in South Staffordshire (No. 11, on the map), is of limited extent, but the

principal bed of coal is 30 feet thick, and varies from 24 to 36 feet, which is a very extraordinary thickness;[1] and there are five other good beds, measuring 4, 4, 8, 7, and 12 feet, the whole thickness of coal being 65 feet. Staffordshire and Worcestershire produce about 11 per cent. of the whole product of the United Kingdom. North Staffordshire, called the Potteries (No. 14), has 40 seams of coal, with a total thickness of 140 feet of coal, of which 22 are large workable beds measuring in all 94 feet. Yorkshire (No. 19 and 20) has 16 seams of coal, with a total thickness of 45 feet, of which the best bed is five or six feet. Leicestershire (No. 10) has ten

seams of a workable size, with 45 feet in all of coal. The Cumberland coal-field has three workable seams. Derbyshire produces the valuable splint coal. (Nos. 16 and 17.)

[1] See plate of working in this thick coal.

Scotland produces 13 per cent. of the coal of the United Kingdom. The great coal-field of Scotland has an extreme length of 94 miles, with an average breadth of 25 miles, and a workable surface of somewhere between 1,450 and 1,750 square miles. In Lanarkshire (No. 28), there are 20 to 30 beds of coal. Clyde (No. 29) has 84 coal-beds; Johnstone (No. 30) has 10 coal-beds—in all 100 feet of coal. The Midlothian (No. 31) has 24 seams, measuring 94 feet. East Lothian (No. 32) has 50 to 60 coal-beds, over one foot thick, in all 188 feet, the thickest being 13 feet. Kilmarnock (No. 33) produces anthracite. Basin No. 34, south of Ayrshire, has 51 feet of coal; and in the Clackman, in Fifeshire, there are 142 coal-seams. In North Wales (Nos. 37, 38, and 39), the coal is bituminous; there are seven beds in all, from 27 to 30 feet thick, the largest being from six to seven feet. The coal-field of South Wales (No. 40) is 54 miles from east to west, and 18 miles in width. The coal-producing rocks are 10,000 feet thick, and a full section shows 25 workable seams above two feet thick, making in all 84 feet of workable coal. The anthracite basins of South Wales, and of the southern part of Ireland (Nos. 47, 48, 49, 50, and 51), are described in Chapter V., on foreign anthracite. Ireland has about 70 collieries, of which 30 are working on old pillars on a small scale, only producing, in all, 165,750 tons in 1871. England, Scotland, and Wales, had 2,730 collieries in 1871. From the following statement it appears there is but little variation, from year to year, in the relative quantity of coal produced in the several districts:

Summary of the Quantities of Coal produced in each Coal District in the United Kingdom, as officially reported.

DISTRICTS.	Nos. on Map.	1865.	1867.	1869.	Average for ten Years, 1860–1869.
Durham and Northumberland	25 26 27	25,033,000	24,867,000	25,765,000	22,741,000
Cumberland	23	1,431,000	1,518,000	1,411,000	1,369,000
Yorkshire	19 20	9,355,000	9,844,000	10,880,000	9,861,000
Derbyshire	16	4,596,000	4,551,000	5,460,000	5,756,000
Nottinghamshire	20	1,095,000	1,575,000	1,575,000	
Leicestershire	10	965,000	1,150,000	651,000	810,000
Warwickshire	9	889,000	881,000	586,000	704,000
Staffordshire and Worcestershire	5 8	12,201,000	12,527,000	12,669,000	10,374,000
Lancashire	18	11,965,000	12,841,000	13,996,000	12,047,000
Cheshire	18	880,000	985,000	957,000	856,000
Shropshire	6 7	1,135,000	1,558,000	1,398,000	1,181,000
Gloucester, Somerset, and Devonshire	1	1,875,000	1,975,000	1,980,000	2,785,000
Monmouthshire	..	4,125,000	4,569,000	4,275,000	3,352,000
South Wales	40	7,912,000	9,092,000	9,180,000	7,806,000
North Wales	36 37	1,983,000	2,371,000	2,155,000	1,997,000
Scotland	..	12,650,000	14,126,000	14,417,000	12,506,000
Ireland	..	124,000	125,000	128,000	125,000
Total		98,151,000	104,500,000	107,428,000	93,925,000

In the year 1866 some degree of public anxiety was awakened in England on the subject of the permanence of their coal-supply. The scientific

journals directed attention to the calculations of Prof. Jevons, and the matter was discussed in Parliament. In June of that year a royal commission was appointed to inquire into the several matters relating to coal in the United Kingdom. After five years of investigation at great expense, with the advantage of paid assistants, and with every facility afforded them for collecting materials, their report was completed in July, 1871, forming three large volumes, in all 1,250 double-column pages, royal quarto size.

"The subjects intrusted to the five committees were: the possible depth of working, waste in combustion, waste in working, the probability of finding coal under the Permian, New Red Sandstone, and other superincumbent strata, and mineral statistics respectively.

"The investigation to determine the maximum depth to which it would be possible to work coal has not been conclusive, but the commissioners consider, from the evidence before them, that it might fairly be assumed that a depth of at least 4,000 feet might be reached. This acknowledgment must give general satisfaction; for, at present, there are only about two mines that have reached one-half of that depth, and, from the experience gained in those, it appears that the high temperature is not in many cases permanent, and is frequently much modified by accidental circumstances. The temperature of the earth is constant at a depth of about 50 feet, and at that depth the temperature is 50° Fahr. The rate of increase in the coal districts is generally about 1° Fahr. for every 60 feet of depth. The heating process is most rapid at first, when the difference of temperature between the air and the strata is greatest, and gradually diminishes as the length of the passage is extended, never ceasing until complete assimilation of temperature. The air takes up the heat much more rapidly in pillar and stall working than in long-wall. The absorption of heat from the strata, by the circulation of the air, gradually lowers the temperature of a mine.

"The labors of Committee C were directed to the inquiry whether there is reason to believe that coal is wasted by bad working, or by carelessness. It seems that the extension of the long-wall system has diminished waste, but much is still lost by bad working and carelessness—a very considerable amount in proportion to that which is actually used. Under favorable systems of working, the loss is about 10 per cent., while, in a very large number of instances, the ordinary waste and loss amounts to 40 per cent.

"With regard to the quantity of coal in known coal-fields, it is estimated that within depths not exceeding 4,000 feet, and after making the necessary deductions, there are (including upward of 130,000,000 tons in Ireland), 90,207,285,398 statute tons; while below 4,000 feet there are 7,320,840,722 tons, making 97,528,126,120 tons in all, and, in the estimate, no consideration has been taken of any bed of coal less than one foot in thickness. To this must be added a further quantity of 56,273,000,000 tons for the probable amount of coal under Permian and other overlying formations at depths of less than 4,000 feet, and deducting 40 per cent. for contingencies, giving an aggregate of 146,480,000,000 tons. Estimating a gradual

increase in the population, and that the consumption per head of population will attain its maximum at the end of the present century, a total consumption is shown of 146,730,000,000 tons in 360 years, so that about Christmas, 2231, we shall have to look for our supply of coal from the sub-Permian deposits, at a depth of below 4,000 feet. The commissioners admit that every hypothesis must be purely speculative, but that if the present rate of increase in the consumption of coal be indefinitely continued, even in an approximate degree, the progress toward the exhaustion of our coal will be very rapid."

This report has been severely criticised in the *British Quarterly Review* for July, 1872. The writer argues that there is no doubt that the increase of temperature is at least 1° Fahr. for every 55 feet in depth, and there is reason to believe that it follows an accelerating ratio. At Monkwearmouth mines, the depth worked is 1,640 feet below the surface, and, in consequence of the high temperature, the men work shorter hours, which involves an increased expenditure. At Rosebridge, the deepest shaft in England, 2,376 feet, the temperature of the earth is 92°. At 2,690 feet, the temperature reaches blood-heat (98°), in which continuous exertion is impossible. The limit to which coal can be extracted, before we commence a steady increase of cost, may be taken at 1,700 feet, and the limit of practicable extraction at 1,000 feet lower. No engineer, who has a reputation to lose, would venture to affix his name to a report that would contemplate the economical working of coal-mines at a lower depth than 2,700 feet. From 1,700 to 2,700 feet there must be a steady increase in the cost of working.

As to the quantity of unmined coal, the estimate includes every thing that is black, and that is more than 12 inches in thickness. It also includes the total cube quantity of coal. As to the very large quantity of coal believed to exist in undiscovered beds, the writer declines to regard the probability of its extraction as being at present a serious question. He figures up but 39,000,000,000 tons as the total quantity of available coal, and that, if the present rate of increase of consumption continues, the last ton of this will be extracted Anno Domini 1945.

It is a mathematical certainty that the exhaustion of a definite quantity of material which is consumed at an annually increased rate is only a question of time. But this is really a narrow and imperfect basis on which to solve the question, how long the supply of coal in England will hold out. It is really, he says, the question of the price at which coal can be laid down in an English port—comparing that paid for the produce of their own mines with that paid for the produce of other coal-fields, including freight—that must determine the question of the activity, or the disuse of the English collieries, whatever may be the amount of coal actually underlying the soil at that time. Within the last year (1872), a very large increase in the wages paid for mining labor, and a great advance in the prices of English coals, have taken place. The proverbial absurdity of "carrying coals to Newcastle" may yet be realized.

There are fifty-nine small coal-basins in FRANCE, of which the most important are those of the Loire, and those of St.-Étienne, which are the best known and the largest, comprising about 50,000 acres. In this basin are 18 beds of bituminous coal, and in the immediate neighborhood are several smaller basins containing anthracite. The total area of coal in France is probably not less than 2,000 square miles. In 1864, the Government engineers estimated there were 800,000 tons of anthracite produced, and of the 12,000,000 of tons, the mean average quantity obtained annually in France, at the present time, about 1,000,000 tons are hard anthracite, and the same quantity of softer anthracite, containing six or seven per cent. of oxygen and hydrogen. The coal-basins of France are on granite or metamorphic rocks, with beds or rather masses of coal of irregular and unequal thickness, sometimes attaining to 40, 60, and 80 feet, and in one or two places 130 feet in thickness, of a local character. Both in their size, and the granite on which they rest, they resemble the coal-basin near Richmond, Virginia.

Production of Coal in France, compiled from the Official Returns in the Report of the Royal Commission.

	Tons, of 2,200 pounds.		Tons, of 2,200 pounds.		Tons, of 2,200 pounds.
1787	211,160	1848	4,017,875	1861	9,125,040
1788	230,962	1849	3,977,344	1862	10,102,116
1789	235,714	1850	4,354,840	1863	10.518,406
1802	829,105	1851	4,404,941	1864	11,046,794
1811	759,878	1852	4,816,306	1865	11,785,714
1816	924,823	1853	5,831,939	1866	11,807,142
1821	1,114,448	1854	6,709,535	1867	12,148,228
1826	1,518,482	1855	7,317,236	1868	13.258,876
1831	1.728,950	1856	7,784,165	1869	13,708,662
1836	2,789,858	1857	7,755,987	1870	6.550,000
1841	3,849,308	1858	7,221,267	1871	No report.
1846	4,389,532	1859	7,337,836	1872	15,000,000
1847	5,065,109	1860	8,155,394		

The BELGIAN coal-field is one of the most important in Europe, but not the most productive, and occupies two districts, that of Liege, containing 100,000, and that of Hainault, containing 200,000 acres. In each, the number of coal-seams is very considerable, but the beds are so thin, and so much disturbed, as to require special modes of working, and they produce various qualities of coal. The small extent of the Belgian coal-field, says L. Simonin, is compensated for by the great number of the coal-seams, and by their numerous and singular zigzag contortions, which have the effect of increasing the quantity in a small, workable surface. All the seams, even to the very thinnest bands, have yielded to the elevating and compressing force, without being fractured, except at certain points ; even the sharp bends in the angles having been produced without under going fracture. In this respect, the formation resembles our anthracite coal-fields.

Production of Coal in Belgium.

	Production.	Exportation.		Production.	Exportation.
1834............		660,012	1854............	7,947,742	2,625,958
1835............		695,586	1855............	8,409,330	2,974,349
1836............	3,056,464	778,612	1856............	8,212,419	2,866,137
1837............	3,228,806	789,083	1857............	8,8·3,902	2,857,012
1838............	3,260,271	775,534	1858............	8,925,714	3,091,316
1839............	3,479,161	745,569	1859............	9,260,702	3,145,235
1840............	3,930,233	779,473	1860............	9,609,895	3,450,306
1841............	4,027,765	1,015,194	1861............	10,057,163	3,379,409
1842............	4,140,462	1,014,716	1862............	9,758,223	2,840,337
1843............	3,982,274	1,086,321	1863............	10,160,590	2,839,348
1844............	4,445,240	1,245,399	1864............	10,959,078	3,264,243
1845............	4,919,156	1,543,472	1865............	11,639,163	3,503,973
1846............	5,037,402	1,355,833	1866............	12,546,541	3,971,273
1847............	5,664,456	1,827,105	1867............	12,544,038	3,564,308
1848............	4,862,694	1,460,570	1868............	12,298,589	3,764,502
1849............	5,251,843	1,664,973	1869............	12,926,894	3,592,790
1850............	5,820,588	1,987,184	1870............	13,697,118	3,182,150
1851............	6,233,517	2,057,050	1871............	13,773,176	3,186,204
1852............	6,795,254	2,108,546	1872............	15,658,948	
1853............	7,172,687	2,331,595			

Production of Coal and Brown Coal in Prussia (Silesia, Rhenish Provinces, Westphalia, and Saxony, etc.), now Germany.

YEARS.	Tons of Coal and Brown Coal.	YEARS.	Tons of Coal and Brown Coal.	YEARS.	Tons of Coal and Brown Coal.
1837............	1,950,915	1863............	16,906,707	1868............	25,704,758
1857............	9,841,220	1864............	19,408,982	1869............	26,774,368
1858............	10,721,323	1865............	21,794,705	1870............	23,316,236
1860............	12,347,828	1866............	21,629,746	1871............	
1861............	14,133,048	1867............	23,73[illegible],327	1872............	
1862............	15,576,278				

The production of 1869 was represented by old Prussia, 23,761,094; Saxony, 2,584,292; Bavaria, 340,571; and the other states of the Zolverein, 88,411; in all, 26,774,368 tons. The coal production of Prussia is larger than that of any other country in Europe. The brown coal included in the above statement is less than one-third of the whole amount.

In PRUSSIA, the coal-measures are said to be 20,000 feet thick, containing 117 seams, in all 294 feet of coal. In another field there are 164 seams, over six inches thick, in all, 338 feet of coal; and of workable seams there are 77 seams with 240 feet of coal in a region 60 miles long by 20 miles wide. Some of the seams are 10, 12, and 14 feet thick, and it is extraordinary that the lowest known seams are bituminous or caking coals, and, the higher they range in the series, the more dry or anthracite do they become. In HUNGARY, there is a brown coal of a good quality, in beds of the thickness of 50, 70, and even 120 feet.

In the province of Asturias, in old Castile, in the northern part of SPAIN, is a coal-field which in length reaches from the frontiers of France to those of Portugal, and in breadth at least eight or 10 miles, and probably much more. It is said to contain 60 coal-seams, and other accounts say upward of 100 workable seams of bituminous coal, from 3 feet to 6½ feet, and some of them even 13½ feet thick, of the very best quality of coal, equal to that of Northumberland and Durham. These beds are variously inclined and contorted, often nearly vertical, and even reversed. The coal-fields of

THE FOLLOWING TABLE EXHIBITS THE ANTHRACITE COAL SENT T

Collect

YEARS.	SCHUYLKILL.			Sold on line of Schuylkill Canal.	LEHIGH.			
	Canal.	Railroad.	Total.		Canal.	Lehigh Valley Railroad.	Lehigh & Susq. Railroad.	
1820....	....	....	....	....	365	....	....	
1821....	....	....	....	....	1,073	....	....	
1822....	1,480	....	1,480	....	2,240	....	....	
1823....	1,128	....	1,128	....	5,823	....	....	
1824....	1,567	....	1,567	....	9,541	....	....	
1825....	6,500	....	6,500	....	28,393	....	....	
1826....	16,767	....	16,767	....	31,280	....	....	
1827....	31,360	....	31,360	....	32,074	....	....	
1828....	47,284	....	47,284	3,154	30,232	....	....	
1829....	79,973	....	79,973	3,332	25,110	....	....	
	186,059		186,059	6,486	166,131			1
1830....	89,984	....	89,984	5,321	41,750	....	....	4
1831....	81,854	....	81,854	6,150	40,966	....	....	4
1832...	209,271	....	209,271	10,048	70,000	....	....	7
1833....	252,971	....	252,971	13,429	123,000	....	....	12
1834....	226,692	....	226,692	19,429	106,244	....	....	10
1835....	339,508	....	339,508	18,571	131,250	....	....	13
1836....	432,045	....	432,045	17,863	148,211	....	....	14
1837....	523,152	....	523,152	21,749	223,902	....	....	22
1838....	433,875	....	433,875	28,775	213,615	....	....	21
1839....	442,608	....	442,608	30,390	221,025	....	....	22
	3,031,960		3,218,019	171,725	1,319,963			1,31
1840....	452,291	....	452,291	28,924	225,318	....	....	22
1841....	584,692	850	585,542	41,223	143,037	....	....	14
1842....	491,602	49,902	541,504	40,584	272,546	....	....	27
1843....	447,058	230,254	677,312	34,619	267,793	....	....	26
1844....	398,887	441,491	840,378	60,000	377,002	....	....	37
1845....	263,587	820,237	1,083,796	90,000	429,453	....	....	42
1846....	3,440	1,233,142	1,236,582	155,460	517,116	....	....	51
1847....	222,693	1,360,681	1,583,374	226,610	633,507	....	....	67
1848....	436,602	1,216,233	1,652,835	252,837	670,321	....	....	67
1849....	489,208	1,115,918	1,605,126	239,290	781,656	....	....	78
	3,790,360	6,468,708	10,258,740	1,169,547	4,317,749			4,31
1850....	288,030	1,423,977	1,712,007	207,863	690,456	....	....	69
1851....	579,156	1,650,270	2,229,426	312,367	964,224	....	....	96
1852....	800,038	1,650,912	2,450,950	322,211	1,072,136	....	....	1,07
1853....	888,695	1,582,248	2,470,943	394,078	1,054,309	....	....	1,05
1854....	907,354	1,987,854	2,895,208	444,160	1,207,186	....	....	1,20
1855....	1,105,263	2,213,292	3,318,555	471,861	1,275,050	9,063	....	1,28
1856....	1,169,453	2,068,903	3,258,356	520,499	1,186,230	165,740	....	1,35
1857....	1,275,989	1,709,552	2,985,541	511,977	900,314	418,235	....	1,31
1858....	1,323,804	1,542,645	2,866,449	441,166	909,000	471,030	....	1,39
1859....	1,372,021	1,632,932	3,004,953	554,774	1,050,659	577,652	....	1,62
	9,709,083	17,482,585	27,192,388	4,181,156	10,309,564	1,641,720		11,95
1860....	1,356,688	1,878,156	3,270,516	608,877	1,091,082	730,642	....	1,82
1861....	1,183,570	1,460,832	2,697,489	485,320	994,705	748,672	....	1,73
1862....	981,729	2,305,606	2,890,598	545,916	896,227	882,573	....	1,35
1863....	885,842	3,065,216	3,433,265	671,589	699,558	1,195,155	....	1,89
1864....	1,000,500	3,065,577	3,642,218	748,418	758,087	1,295,419	....	2,05
1865....	1,022,740	3,090,814	3,735,802	746,623	888,784	1,402,277	....	1,82
1866....	1,297,047	3,714,644	4,633,487	1,010,905	1,066,308	1,730,475	....	2,12
1867....	1,030,235	3,446,826	4,334,820	1,107,826	1,006,601	1,948,385	....	2,06
1868....	987,628	3,574,874	4,414,356	1,037,053	989,947	2,603,103	1,058,054	2,50
1869 ...	698,879	4,239,457	4,748,969	730,913	605,144	2,310,170	1,297,825	1,92
	10,444,858	29,842,002	37,801,521	7,643,476	8,496,391	14,841,871	2,355,879	19,31
1870....	526,804	3,750,990	3,720,403	1,189,164	789,112	3,608,587	1,354,052	2,99
1871....	1,010,171	4,584,450	5,124,780	1,223,040	740,636	2,889,074	1,933,587	2,94
1872....	838,191	4,866,[illegible]	5,207,451	1,471,431	767,094	3,877,179	2,527,069	3,61
	29,538,201	66,995,264	92,709,360	17,056,022	26,896,640	26,858,431	8,170,587	45,91

☞ In making up this table, the coal transported over all the railroads is given in credited to the different regions, so that the

Asturias are likely hereafter to be ranked among the most valuable in Europe, but at present the production is small. Reducing their metric quintals to tons of 2,240 lbs., the production in 1864 was 175,595 tons; in 1865, 208,864; in 1866, 177,776 tons; and 550,387 tons in 1869, besides 39,420 tons of lignite.

The great majority of the deposits of coal in Austria are found in the northwest portion of the empire, and the Tertiary deposits do not yield in importance to the more ancient formations. The following tabular statements contain all that would afford much interest to American readers.

Quantities of coal and brown coal produced in each province in 1862, that of Bohemia being the largest, the Austrian centners being reduced to tons of 2,240 lbs.: (See also pages 676 and 677.)

PROVINCES.	Tons.	PROVINCES.	Tons.
Lower Austria	189,290	Galicia	190.916
Upper Austria	126,453	Dalmatia	7,886
Styria	490,961	Lombardy	....
Illyria	190,419	Venetia	16,116
Coast-land	13,216	Hungary	561,839
Tyrol	4,828	Bannat	22,169
Bohemia	2,078,188		
Moravia and Silesia	626,594	Total	4,525,763

Production of Coal and Brown Coal in the Austrian States, in Gross Tons.

YEARS.	Tons.	YEARS.	Tons.	YEARS.	Tons.
1823	134,216	1840	469,663	1857	
1824	149,380	1841	526,714	1858	
1825	153,361	1842	519,825	1859	
1826	171,308.	1843	516,464	1860	
1827	173,341	1844	639,169	1861	
1828	171,871	1845	715,979	1862	
1829	167,289	1846	793,828	1863	
1830	208,256	1847	827,409	1864	
1831	195,778	1848	No returns.	1865	
1832	212,140	1849	No returns.	1866	
1833	194,263	1850	1,116,906	1867	
1834	235,547	1851	1,354,487	1868	
1835	243,798	1852	1,668,475	1869	
1836	271,563	1853	1,735,342	1870	
1837	280,666	1854	1,642,254	1871	
1838	332,358	1855	2,064,375	1872	
1839	426,696	1856	2,319,888		

II. IN THE UNITED STATES.

There can be no more deceptive statement made in regard to the American coal-fields, which may be at the same time true, than that of their area only. But the reader, who is presumed to have read the preceding portion of this work, will be thereby enabled to discriminate between good and bad quality, thick and thin seams, their nearness to the surface, and the facilities for mining and transportation to a good market; but especially between good and bad quality. In order that no one may be misled by mere size, the following tabular statement of the areas of the coal-fields in each State is accompanied by another, giving the annual production of each, so as to lead to a more just estimate of their present importance. The State of Kansas contains far more square miles of coal than Pennsylvania; yet the large bed in the little Hazelton Basin, five miles long, and

less than one mile wide, is worth more than all the coal in Kansas. The fourth great coal-field, or that in the States of Iowa, Missouri, Nebraska, and Kansas, contains 64,887 square miles of surface, and great as is its importance in that vast, fertile, treeless, prairie country, yet it cannot be compared, in any respect but size, to the first or Alleghany coal-field in the States of Pennsylvania, Ohio, Maryland, West Virginia, Eastern Kentucky, Tennessee, and Alabama, containing 58,737 square miles, the coal in the latter being so much better. But, in any view that may be taken, we should be content with our bountiful stores of coal, although it is not all of equally good quality.

Area of the Coal-fields of America, and their Annual Production.

STATES CONTAINING COAL.	Area in square miles.	Tons produced, by Census Report, 1869–'70.	Tons produced in 1872. Estimated.
1. Pennsylvania Anthracite	472	15,648,437	19,000,000
" Bituminous	12,302	7,800,356	10,442,000
2. Maryland (Big Bed, 23 miles)	550	2,345,153	2,355,500
3. West Virginia (Taylor, 21,195)	16,000	608,878	700,000
4. Ohio	10,000	2,527,285	3,000,000
5. East Kentucky	8,983	35,488	40,000
6. Tennessee	5,100	133,418	200,000
7. Alabama (First Coal-field, 58,737)	5,330	11,000	15,000
8. Michigan (Second Coal-field)	6,700	28,150	30,000
9. Indiana	6,450	437,870	800,000
10. Illinois	36,800	2,624,163	3,000,000
11. West Kentucky (Third Coal-field, 47,138)	3,888	115,094	300,000
12. Iowa	18,000	263,487	300,000
13. Missouri	26,887	621,930	700,000
14. Nebraska	3,000	1,425	1,500
15. Kansas (Fourth Coal-field, 64,887)	17,000	32,938	40,000
16. Arkansas	9,043	......	......
17. Texas	4,500	......	......
18. Virginia	185	61,803	62,000
19. North Carolina	310	......	......
20. Massachusetts, and 21. Rhode Island	500	14,000	14,000
Totals [1]	192,000	33,810,905	41,000,000

Census Report of Coal mined in each County in the United States for the Year ending June 1, 1870. *Also the Number of Mines worked, and the Men and Boys employed.*

STATES AND COUNTIES.	Mines.	Men and Boys.	Tons.	STATES AND COUNTIES.	Mines.	Men and Boys.	Tons.
1. ANTHRACITE.				2. BITUMINOUS COAL.			
Pennsylvania.				*Alabama.*			
Carbon	4	1,214	403,384	De Kalb	1	50	10,000
Columbia	8	2,308	400,876	Shelby	1	7	1,000
Dauphin	5	1,732	411,355	Total	2	57	11,000
Luzerne	90	28,016	9,519,298	*Illinois.*			
Northumberland	29	3,965	1,053,380	Bureau	9	110	32,339
Schuylkill	91	15,778	3,860,144	Christian	1	3	60
	227	53,008	15,648,437	Clinton	1	35	9,000
Rhode Island.				Fulton	7	71	22,850
Newport	2	75	14,000	Gallatin	2	48	11,600
Total Anthracite	229	53,083	15,662,437	Grundy	16	291	51,375

[1] The total area of the 37 United States is 1,950,171 square miles, without the Territories. The coal-area is, therefore, one square mile in ten. The area of the 10 Territories is 965,032 square miles, making an aggregate of 2,915,203 square miles. The area of lignite in the Territories is not known.

Census Report of Coal (continued).

STATES AND COUNTIES.	Mines.	Men and Boys.	Tons.
Henry	8	230	62,750
Jackson	2	551	166,800
Jersey	6	15	2,623
Knox	44	214	97,225
La Salle	5	879	178,864
Livingston	10	144	49,360
Logan	1	88	17,000
McDonough	17	220	60,750
McLean	2	250	55,000
Macoupin	1	25	7,000
Madison	15	207	116,924
Marshall	9	51	17,330
Menard	5	45	17,360
Mercer	16	72	14,040
Montgomery	1	30	18,000
Peoria	1	17	6,000
Perry	9	390	195,400
Randolph	2	18	11,000
Rock Island	12	354	127,680
Sangamon	6	246	84,500
Schuyler	4	22	8,100
Scott	4	11	2,950
Shelby	5	18	5,700
Stark	13	60	14,554
St. Clair	42	1,112	798,810
Tazewell	3	24	5,300
Vermilion	14	259	115,640
Warren	22	72	11,729
Will	3	642	228,000
Williamson	3	7	1,600
Woodford	1	25	4,000
Total, Illinois	322	6,301	2,624,163
Indiana.			
Clay	15	635	236,642
Davies	5	369	64,338
Fountain	2	17	3,132
Greene	2	5	270
Macon	1	47	4,000
Parke	2	7	2,040
Perry	1	130	28,572
Pike	3	8	1,600
Sullivan	1	48	24,000
Vandenburg	1	37	10,710
Vigo	9	77	33,980
Warren	1	3	250
Warrick	3	86	28,336
Total, Indiana	46	1,369	437,870
Iowa.			
Adams	1	3	100
Appanoosa	17	65	6,709
Boone	5	262	42,143
Davis	3	8	1,080
Hamilton	1	3	300
Jasper	6	156	20,720
Jefferson	3	30	5,300
Keokuk	4	27	3,400
Mahaska	8	129	82,550
Marion	7	28	4,318
Monroe	8	35	15,410
Muscatine	4	27	2,492
Polk	6	174	45,600
Scott	5	82	17,325
Wapello	11	193	81,630
Warner	5	17	1,860
Wayne	1	5	155
Webster	6	110	32,487
Total, Iowa	96	1,354	263,487

STATES AND COUNTIES.	Mines.	Men and Boys.	Tons.
Kansas.			
Bourbon	11	42	7,717
Crawford	2	6	1,508
Ellsworth	1	35	1,678
Osage	4	162	20,635
Shawnee	2	7	1,400
Total, Kansas	20	252	32,938
Eastern Kentucky.			
Boyd	4	10	2,236
Clinton	1	75	7,143
Greenup	2	59	25,180
Murphy	1	2	214
Rock Castle	1	15	715
Western Kentucky.			
Butler	2	15	4,420
Crittenden	2	141	23,600
Hancock	2	31	8,000
Henderson	2	20	8,800
Hopkins	1	2	1,450
Davies	2	21	2,888
Livingston	1	14	1,800
Muhlenburg	1	2	820
Union	5	269	67,466
Webster	3	8	850
Total, Kentucky	30	125	115,094
Maryland.			
Alleghany	...	....	2,345,153
Michigan.			
Ingham	1	8	150
Jackson	2	85	28,000
Total, Michigan	3	93	28,150
Missouri.			
Adrien	3	4	1,200
Bates	3	11	1,923
Boone	5	15	1,380
Callaway	4	18	2,450
Cole	1	6	1,357
Cooper	1	30	3,000
Henry	2	5	900
Johnson	2	32	8,000
Linn	4	12	2,100
Livingston	1	6	600
Macon	3	289	75,282
Moniteau	1	6	1,000
Randolph	4	86	27,200
Ray	6	126	43,844
St. Charles	4	27	5,400
St. Louis	9	1,183	444,642
Schuyler	2	19	1,400
Warren	1	3	250
Total, Missouri	56	1,878	621,930
Nebraska.			
Pawnee	3	8	1,425
Pennsylvania.			
Alleghany	68	6,099	2,637,269
Armstrong	11	312	186,465
Beaver	16	83	28,020

Census Report of Coal (continued).

STATES AND COUNTIES.	Mines.	Men and Boys.	Tons.
Bedford	6	252	115,200
Blair	6	191	161,850
Bradford	2	750	350,900
Butler	46	149	63,118
Cambria	3	527	244,298
Centre	7	302	184,456
Clarion	9	103	55,540
Clearfield	11	279	181,237
Elk	2	142	78,779
Fayette	22	447	453,580
Huntingdon	7	334	163,693
Indiana	23	103	33,082
Jefferson	3	8	3,092
Lawrence	11	245	129,810
Lycoming	1	30	2,000
McKean	1	60	21,958
Mercer	34	1,993	659,875
Somerset	11	25	6,510
Tioga	3	1,683	733,562
Venango	11	103	36,230
Warren	1	2	200
Washington	27	1,042	510,077
Westmoreland	19	1,559	755,460
Total, Pennsylvania Bituminous Coal	361	3,487	7,800,856
Ohio.			
Athens	11	356	131,140
Belmont	21	264	123,901
Carroll	1	2	400
Columbiana	15	608	209,677
Coshocton	9	399	73,026
Guernsey	13	134	73,389
Harrison	21	79	16,990
Hocking	2	140	75,560
Holmes	5	29	10,069
Jackson	20	245	74,821
Jefferson	9	680	266,830
Lawrence	3	165	56,390
Licking	1	1	400
Mahoning	16	890	108,880
Medina	1	12	5,000
Meigs	9	1,105	268,700
Morgan	3	7	750
Muskingum	26	192	67,078
Noble	7	14	2,675
Perry	2	7	1,350
Portage	1	8	1,500
Stark	46	501	131,257
Summit	4	165	56,738
Trumbull	21	1,699	628,279
Tuscarawas	25	270	110,435
Vinton	6	36	6,660
Washington	4	25	3,770
Wayne	5	54	21,650
Total, Ohio	307	7,567	2,527,285

STATES AND COUNTIES.	Mines.	Men and Boys.	Tons.
Tennessee.			
Anderson	2	58	22,750
Campbell	1	20	16,000
Grundy	1	140	35,714
Hamilton	2	6	11,000
Marion	4	165	36,529
Roane	1	30	11,425
Total, Tennessee	11	419	133,418
West Virginia.			
Boone	1	90	40,000
Brooke	4	48	15,120
Hancock	2	4	1,620
Harrison	4	205	110,100
Kanawha	11	305	168,800
Marion	1	83	40,000
Mineral	2	188	95,300
Monongalia	2	3	2,400
Ohio	5	29	15,280
Preston	2	143	88,000
Ritchie	5	38	30,704
Taylor	2	4	1,604
Total, W. Virginia	41	1,140	608,878
Virginia.			
Chesterfield	3	610	57,125
Henrico	1	11	3,000
Montgomery	1	6	250
Prince Edward	1	15	1,423
Total, Virginia	6	642	61,808
3. LIGNITE.			
Colorado.			
Jefferson	2	13	3,500
Weld	1	3	1,000
Total, Colorado	3	16	4,500
Wyoming.			
Carbon Station	1	165	50,000
Washington.			
Whatcom	1	80	17,844
Utah.			
San Pete	1	5	300
Summit	5	20	5,500
Total, Utah	6	25	5,800

Summary of the Census Report of the Coal Trade of the United States.

STATES AND TERRITORIES.	No. of Mines.	MEN EMPLOYED.		BOYS EMPLOYED.		Total Men and Boys.	Tons of Coal mined.
		Above-ground.	Under-ground.	Above-ground.	Under-ground.		
1. ANTHRACITE.							
Pennsylvania	227	13,808	30,092	5,500	3,578	53,008	15,648,437
Rhode Island	2	28	42	5	.....	75	14,000
Total, Anthracite	229	13,836	30,134	5,505	3,578	53,083	15,662,437

Summary of the Census Report (continued.)

STATES AND TERRITORIES.	No. of Mines.	MEN EMPLOYED. Above-ground.	MEN EMPLOYED. Under-ground.	BOYS EMPLOYED. Above-ground.	BOYS EMPLOYED. Under-ground.	Total Men and Boys.	Tons of Coal mined.
2. BITUMINOUS.							
Alabama	2	24	33	.....	.....	57	11,000
Illinois	322	1,058	5,108	135	.....	6,301	2,624,163
Indiana	46	243	1,056	70	.....	1,369	437,870
Iowa	96	391	950	13	.....	1,354	263,487
Kansas	20	248	4	.....	.....	252	32,938
Kentucky	30	401	275	37	1	714	150,582
Maryland (C. Slack)	6	176	1,322	.....	.....	1,498	2,345,153
Michigan	3	34	51	8	.....	93	28,150
Missouri	56	593	1,285	.....	.....	1,878	621,930
Nebraska	3	6	.....	2	.....	8	1,425
Ohio	307	1,911	5,335	321	.....	7,567	2,527,285
Pennsylvania	361	3,487	13,043	29	305	16,864	7,800,356
Tennessee	11	196	203	20	.....	419	133,418
Virginia	6	255	387	.....	.....	642	61,803
West Virginia	41	414	629	28	69	1,140	608,878
Total, Bituminous	1,310	9,437	29,681	663	375	40,156	17,648,468
3. LIGNITE.							
Colorado	3	4	12	.....	.....	16	4,500
Washington	1	20	60	.....	.....	80	17,844
Wyoming	1	79	80	.....	15	165	50,000
Utah	6	5	20	.....	.....	25	5,800
Total, Lignite	11	99	172	.....	15	286	78,144
Total of all kinds	1,550	23,402	59,987	6,168	3,968	93,525	33,339,049

Financial Statistics of the Coal Trade, as reported by the Census of 1870.

STATES AND TERRITORIES.	Capital.	Wages.	Materials.	Products.
1. ANTHRACITE.				
Pennsylvania	$50,922,285	$22,970,318	$3,594,958	$38,422,445
Rhode Island	80,000	33,000	4,100	59,000
Total, Anthracite	$51,002,285	$23,003,318	$3,599,058	$38,481,445
2. BITUMINOUS.				
Alabama	$26,000	$28,970	$351	$39,000
Illinois	4,286,575	3,192,977	399,334	6,097,432
Indiana	554,442	664,592	61,890	968.621
Iowa	618,332	580,157	73,102	874,834
Kansas	106,430	89,191	2,601	114,278
Kentucky	717,950	278,411	27,828	446,795
Maryland	14,466,600	802,482	49,217	1,125,133
Michigan	176,500	58,400	7,550	104,200
Missouri	2,587,250	1,277,804	316,082	2,011,820
Nebraska	850	2,950	1,450	8,550
Ohio	5,891,813	3,381,108	252,447	5,482,952
Pennsylvania	16,989,418	9,007,995	606,173	13,935,369
Tennessee	313,784	187.383	15,945	330.498
Virginia	779,200	168,120	20,812	226,114
West Virginia	1,434,800	619,376	48,564	1,035,862
Total, Bituminous	$48,949,944	$20,334,916	$1,882,846	$32,820,958
3. LIGNITE.				
Colorado	$36,000	$9,000	$2,410	$16,500
Washington	300,000	70,869	13.394	107,064
Wyoming	250.000	225,000	48,000	800.000
Utah	448,000	2,550	5,985	14,950
Total, Lignite	$630,800	307,419	$69,789	$938,514
Total of all kinds	$100,583.029	$43,645,648	$5,551,693	$72,240,917

DETAILS OF THE PRODUCTION OF BITUMINOUS COAL IN PENNSYLVANIA.

Statistics of the Several Varieties of Bituminous Coal mined in Pennsylvania in 1871, derived from Reports made to the Auditor-General and other Authentic Sources.

OPERATOR OR COMPANY.	Railroad, or locality.	Tons each Mine.	Tons each County.
I. SEMI-BITUMINOUS COAL.			
BRADFORD COUNTY.			
Towanda Coal Company	Barclay Railroad	263,928	
Fall Creek B. C. Company	" "	129,095	
			393,023
TIOGA COUNTY.			
Fall Brook Coal Company	Tioga Railroad	233,658	
Wilson Creek Mines	Local use	1,847	
Morris Run Coal Company	Tioga Railroad	386,247	
Blossburg Coal Company	" "	198,091	
			819,843
LYCOMING, CENTRE, & CLEARFIELD CO'S.			
McIntyre Coal Company	N. C. Railroad		106,129
Bellefonte & S. R. Company	B. & S. S. Railroad		82,463
CLEARFIELD CO. OR PHILLIPSBU'G REGION.[1]			
Powelton Coal and Iron Company	Sandy Ridge	61,528	
" " "	Osceola	34,088	
Moshannon Coal Company	Moshannon	68,000	
Kittanning Coal Company	Beaverton Br.	70,699	
White & Lingle	Eureka	86,888	
D. Houtes	Franklin	58,605	
Blattenburger & Hines	Pennsylvania	11,265	
Enterprise Coal Company	Decatur	5,640	
J. A. G. White & Company	Mapelton	28,852	
Union Coal Company		1,297	
Derby Coal Company	Decatur	18,182	
David W. Holt	Morrisdale	67,780	
Several other companies not reported		91,107	
			542,896
Used by the Pennsylvania Railroad Co.		26,161	
Carried as freight by " "		516,735	
CAMBRIA COUNTY.			
Cambria Iron Company	In Iron Works	241,847	
George Delaney	Local use	600	
Lemon & Bradley	Pennsylvania Railroad.	21,456	
Mentzer & Rothrock	" "	16,842	
James M. Cooper	" "	6,209	
A. J. Fogle	" "	3,465	
Acker & Blackmer	" "	10,021	
William Tiley	" "	3,546	
James H. Dysert	" "	2,842	
South Fork Coal and Iron Company	" "	15,642	
Cambria Iron Company, S. A. Logan	Local	150	
Other mines not reported[2]		148,144	
			470,264
HUNTINGTON AND BEDFORD COUNTIES.			
Broad Top Mountain Region		310,594	
Used by the B. T. R. R. Company		9,094	
			319,618
Total Semi-bituminous			2,738,741

[1] Analysis of Moshannon Creek Coal: Carbon, 71.563; volatile matter, 18.570; ashes, 6.560; water, 2.460; sulphur, 0.847. The volatile matter contains 3.187 of hydrogen. Dated April, 1872.

[2] The Pennsylvania Railroad received for transportation on the west slope of the Alleghany Mountain 228,808 tons, requiring this addition to the quantities reported by the mines enumerated. The coal of the Cambria Iron Works was not carried by the railroad.

Production of Bituminous Coal in Pennsylvania (continued).

OPERATOR OR COMPANY.	Railroad, or locality.	Tons each Mine.	Tons each County.
II. BITUMINOUS COAL.			
CLINTON AND ELK COUNTIES.			
Karthaus Coal Company	P. & E. Railroad	8,564	
St. Mary's Coal Company	" "	74,056	
Benzinger Coal Company	" "	18,202	
Toby's C'k & Phil. O. & C. Co	" "	13,652	
Duyascahonda Imp. Co	" "	2,363	
			116,897
McKEAN AND JEFFERSON COUNTIES.			
Longwood Coal Co	Carrolton, E. R		1,406
Seven country pits	Local		5,017
ARMSTRONG COUNTY.			
Brady's Bend Iron Co	Snow Hill & Summit	112,200	
McKnight, Porter & Co	Monticello Furnace	24,095	
Brown & Morgan	Pine Creek	15,639	
J. A. Calwell & Co	Mahoning Furnace	18,660	
J. E. Bowen	To Oil City	5,800	
F. B. & A. Lamblin	Stewartson Furnace	10,815	
Nine country pits	For local use	11,480	
			198,689
CLARION COUNTY.			
Red Bank Furnace	Used in furnace		25,996
WARREN COUNTY.			
David Dinsmore	For local use		1,000
VENANGO COUNTY.			
On Jamestown & Franklin Railroad	At Raymilton	18,714	
" Jamestown & Franklin Railroad	Cranberry	11,872	
" Jamestown & Franklin Railroad	French Creek	1,500	
			32,086
BUTLER COUNTY.			
B. F. Hitchcock	Alleghany Township	13,000	
H. Bean & W. H. Nealey	Butler "	16,627	
—— Edwards	" "	7,275	
William Rogers	Furnace	5,000	
John Pierce	Alleghany	8,000	
Thirteen country pits	For local use	11,582	
			61,484
INDIANA COUNTY.			
Reported in gross		61,017	
Points on West Pennsylvania Railroad		142,681	
			203,698
MERCER COUNTY.			
On Jamestown & Franklin Railroad		54,947	
Mercer Iron and Coal Co		63,760	
Carwiler, Angler, Wheeler & Egbert		17,800	
Mer. Min. & M. Co	Shen. & Al. Railroad	46,686	
Ride & Co	Local	1,400	
D. C. Emery	Local	1,149	
			185,742
LAWRENCE COUNTY.			
Clinton Coal Co		25,334	
Other parties		61,084	
			86,418
On Newcastle and Beaver V. Railroad		86,418	
" Lawrence Br. Railroad		2,548	
Neshannock R. R. and Ore Co		32,186	
			121,152
BEAVER COUNTY.			
Onondaga Coal Co		40,146	
Pulaski Township	For fire-brick	4,300	
Industry Salt Works	For salt	1,145	
Clear. and Pitts. Railroad	C. & P. Railroad	421	
Clayton Mines		4,378	
Hookstown Mines		977	
Darlington Coal Co.'s Railroad		39,158	
Pitts., Ft. W. & C. Railroad		15,874	
			106,389

Production of Bituminous Coal in Pennsylvania (continued).

OPERATOR OR COMPANY.	Railroad, or how used.	Tons each Mine.	Tons each County.
WASHINGTON AND ALLEGHANY COUNTIES.			
D. Stien & Son	P.H. or P.C.&St.L.R.R.	42,011	
Negley & Co	" "	33,020	
Mansfield Coal & L. Co	" "	35,888	
Fort Pitt Coal Co	" "	34,117	
Pittsburg Union Coal Co	" "	3,565	
Chicago & Pittsburg M. & F. Co	" "	3,275	
Pennsylvania Coal Co	" "	759	
Chicago and Pittsburg M. & T. Co	" "	3,316	
Pitts. Nat. C. & C. Co	" "	37,606	
Willow Grove Mines	" "	3,179	
N. Y. & Clear. G. C. Co	" "	21,210	
Pitts. Walnut Hill Co	" "	23,431	
Midway Mines	" "	9,656	
Whitestown Coal Company	" "	6,297	
Burgettville Coal Co	" "	110	
Used by the P. C. & St. L. L. Railroad		6,458	
Total			336,798

Monongahela Slack-water Navigation.

OPERATOR OR COMPANY.	Townships.	Tons.
John Carlin & Co	Chartiers	23,351
Wittingill & Gowley	"	19,069
R. & J. Watson	Chartiers and St. Clair	27,261
John O'Neil	" "	29,061
Horner Wood & Co	Baldwin	22,813
Hoberman & Co	"	24,385
Robbins & Jenkins	Lincoln	39,539
Neish & Brothers	Forward	11,366
John C. Riskie & Co	Mifflin	65,892
J. D. Kister	"	23,047
Joseph Walton & Co	W. Elizabeth	73,022
J. N. O'Neil & Co	"	60,000
Horner and Roberts	Elizabeth	28,275
William McGill	"	23,438
James O'Neil	"	31,369
Duncan Cornell & Co	McKeesport	51,670
J. C. Perry	Youghiogheny River	16,949
Bridgeport Coal Co	Fayette City	100,000
Miller, Crawford & Co	Bridgeport	4,000
E. Furlong	Jefferson	7,100
Robert S. Niles	"	12,000
Mark Hamet	"	69,001
Robert Wellington	Brownsville	37,710
William J. Forsyth	Pool No. 4	3,595
J. Turnbridge		5,000

There are many others not reported, but the total quantities shipped on the Monongahela Navigation in 1871 were as follows:

POOLS.	Counties.	Tons.	
From Pool number 1	Alleghany, Fayette, and Washington	264,715	
" " " 2		1,039,250	
" " " 3		315,415	
" " " 4		228,229	
Reckoning 25 bushels to one ton.			1,847,609

Other Mines in Alleghany, Fayette, and Westmoreland Counties, chiefly on the Pittsburg and Connellsville Railroad.

OPERATOR OR COMPANY.	Location.	Tons.	Total Tons.
William H. Brown		117,813	
H. B. Hays & Co	Beck's Run & 6 M. F.	64,728	
Corey & Co		67,294	
N. J. Bigley		19,560	
Youghiogheny G. C. Co.		1,420	
Pitts. & Conn. G. C. & Coke Co		49,024	
Frick & Co	Broad Ford	20,000	
Morgan & Co	" "	55,000	
Merkle & Shenck	" "	8,972	
Brown & Cochran	Tyrone Township	40,000	
James Cochran	" "	57,851	
Cochran & Stechler	" "	8,710	
Laughlin & Co	" "	46,800	
Cochran & Heister		7,658	
Connellsville Gas Coal Co		46,767	
Charles H. Armstrong		51,615	
Frazier & Fryer		17,090	
Taylor, Watt & Co	Dunbar	25,118	
E. M. Ferguson	"	4,855	
Thomas H. Frost	Frost's Station	5,500	
Samuel Clark & Sons	Turnout	39,594	
Thomas Moore		86,440	
O. F. Lamm & Co		9,000	
Robson, Campbell & Co		5,000	
Philadelphia & Youghiogheny Coal Co	Osceola Station	81,985	
John Moyers	Mount Pleasant	2,984	
Henry R. Benson	Union	1,954	941,662
Alleghany Valley Railroad.			
Keir & Foster	Sandy Creek	129,883	
Armstrong, Dickson & Co	Penn Township	66,940	
W. Coleman & F. Rahm	" "	28,169	
Pennsylvania Salt Manufacturing Co	National	24,830	
Kipp, Lockhart & Co	Lockhart Station	3,600	
Brown & Williams	" "	2,940	256,362
Vicinity of Pittsburg.[1]			
Little Saw-mill Run Railroad			159,201
Duquesne Coal Co	Pa. Railroad West	48,110	
Braddock's Field Coal Co	" " "	55,698	
Dickson, Stewart & Co	" " "	83,518	
Other mines between Brinton and Pittsb'g.		35,577	217,898
Pennsylvania Salt Manufacturing Co	For Salt Manufacture	24,830	
Pittsburg Coal and Mining Co	By River	47,725	
Joseph Walton & Co	"	78,022	
Enterprise Coal Co	"	60,000	
Winona Coal Co	"	11,866	
Morgan Mines	"	5,500	
Eagle Mines	"	8,972	231,915
Westmoreland County.			
Westmoreland Coal Co		450,390	
Pennsylvania Gas Coal Co		378,599	
Shafton Coal Co		27,000	
Powelton Coal and Iron Co		10,509	866,498
Greene County.			
14 Country pits	For local use		14,458
Total Bituminous Coal			5,752,648

[1] There is great difficulty in making an accurate statement of the production of coal in Alleghany and Fayette Counties, on account of the very large local consumption of coal received directly from the mines by iron-works, salt-works, and other manufactories, or converted into coke, and considerable quantities are also sent down the river without passing over any railroad or slack-water navigation. These statistics, amounting to nearly 4,000,000 tons, are the first attempt at a detailed report of the bituminous coal-trade of this important district. They are good as far as they go, but must be regarded as an approximation only. There is a large increase in 1879.

Other Mines in Mercer County.

OPERATOR, ETC.	Railroad, etc.	Tons.	Total Tons.
III. SPLINT OR BLOCK COAL.			
MERCER COUNTY.			
Keel Ridge Mine, Kimberly, Forbes & Co.	E. P. & R. R.	57,917	
Mt. Pleasant, K., F. & Co	" "	53,654	
Lackawanna Mine, Forbes & Kimberly	" "	11,687	
J. Forbes & Co	" "	40,755	
" "	Erie Canal	1,400	
" "	Local	1,000	
" "	Furnace	19,245	
J. W. Ormsby & Son	E. & P. R. R.	32,510	
Others at Sharpsville, by	"	77,720	
Middlesex	"	53,880	
Wheatland	"	40,057	
Sharon	"	33,425	
Total Block Coal			423,200
RECAPITULATION.			
Semi-bituminous Coal			2,733,741
Bituminous Coal			5,752,643
Block Coal			423,200
Total Bituminous Coal of all kinds			8,909,584

Statistics of the Blossburg Region, in Tioga County, Pa.

YEARS.	OLD BLOSSBURG MINES. Arbon Coal Co.	OLD BLOSSBURG MINES. W. M. Mallory.	OLD BLOSSBURG MINES. D. S. Magee.	MORRIS RUN. Morris Run Coal Co.	FALL BROOK. Fall Brook Coal Co.	ARNOT. Blossburg Coal Co.	Total Tons.
1840	4,235	......	......	......	......	......	4,235
1841	25,966	......	......	......	......	......	25,966
1842	13,164	......	......	......	......	......	13,164
1843	6,268	......	......	......	......	......	6,268
1844	......	14,234	......	......	......	......	14,234
1845	......	29,836	......	......	......	......	29,836
1846	......	16,509	......	......	......	......	16,509
1847	......	29,087	......	......	......	......	29,087
1848	......	33,762	......	......	......	......	33,762
1849	......	32,095	......	......	......	......	32,095
1850	......	23,161	......	......	......	......	23,161
1851	......	25,000	......	......	......	......	25,000
1852	......	20,000	......	......	......	......	20,000
1853	......	35,326	......	10,181	......	......	45,507
1854	......	46,379	......	23,835	......	......	70,214
1855	......	41,728	......	31,476	......	......	73,204
1856	......	32,727	3,077	34,865	......	......	70,669
1857	......	25,272	27,379	41,663	......	......	94,314
1858	......	......	20,426	21,468	......	......	41,894
1859	......	......	28,114	20,478	......	......	48,592
1860	......	......	......	25,569	71,349	......	96,918
1861	......	......	......	32,993	79,719	......	112,712
1862	......	......	......	41,868	137,966	......	179,834
1863	......	......	......	93,243	142,600	......	235,843
1864	......	......	......	209,839	175,138	......	384,977
1865	......	......	......	242,866	151,776	......	394,642
1866	......	......	......	263,872	141,353	6,534	411,759
1867	......	......	......	281,659	159,318	40,341	481,318
1868	......	......	......	330,749	199,648	72,931	603,328
1869	......	......	......	389,673	218,351	107,070	715,094
1870	......	......	......	360,472	241,750	130,818	733,035
1871	......	......	......	385,994	232,632	196,453	815,079
1872	......	......	......	318,079	233,694	297,489	849,262
	[1]49,633	[1]405,116	[1]78,996	3,160,342	2,185,294	351,631	6,731,012

[1] Total tons, Old Blossburg Mines, 533,745.

The Towanda Coal-Trade.—The following table shows the amount of coal shipped from the Barclay coal-region since it was first opened:

YEARS.	Barclay Coal Co.	Towanda Coal Co.	Fall Creek Coal Co.	Total Production.
1856	2,275	......	......	2,295
1857	6,265	......	......	6,265
1858	17,560	......	......	17,560
1859	30,143	......	......	30,143
1860	27,718	......	......	27,718
1861	40,835	......	......	40,835
1862	52,779	.....	......	52,779
1863	54,535	......	......	54,535
1864	62,058	......	......	62,058
1865	48,375	7,886	16,936	73,197
1866	37,968	31,881	29,604	99,453
1867	30,119	27,668	16,953	74,739
1868	......	67,080	6,595	73,675
1869	......	176,307	4,303	180,610
1870	......	196,310	77,025	273,335
1871	......	249,240	129,095	378,335
1872	......	263,960	118,882	382,842
	410,650	1,020,332	399,592	1,830,874

The Sullivan County semi-anthracite was first sent to market in September, 1871. Amount shipped that year, 24,665 tons, and in 1872, 54,966 tons. Analysis of this coal: Carbon, 89.29; ashes, 5.65; volatile matter chiefly water, 5.06. Production in 1873, 35,267 tons.

Semi-Bituminous Coal carried by the Huntington & Broad Top Mountain Railroad, in Pennsylvania.

YEARS.	Tons.	YEARS.	Tons.	YEARS.	Tons.
1856	42,000	1862	333,606	1868	280,936
1857	78,818	1863	305,678	1869	360,779
1858	105,478	1864	336,645	1870	318,425
1859	130,595	1865	315,996	1871	319,625
1860	186,903	1866	265,720	1872	297,473
1861	272,625	1867	244,412	1873	350,246

Semi-Bituminous Coal carried on the Bellefonte & Snowshoe Railroad.

YEARS.	Tons.	YEARS.	Tons.	YEARS.	Tons.
1862	8,260	1866	70,890	1870	85,276
1863	12,039	1867	58,187	1871	79,984
1864	33,598	1868	60,149	1872	68,968
1865	51,881	1869	89,356	1873	95,257

Bituminous Coal carried on the Philadelphia & Erie Railroad.

YEARS.	Tons.	YEARS.	Tons.	YEARS.	Tons.
1862	5,385	1866	36,359	1870	51,445
1863	12,787	1867	51,161	1871	45,690
1864	27,777	1868	55,242	1872	83,885
1865	26,042	1869	64,857	1873	81,742

Coal carried on the Little Saw-Mill Run Railroad, near Pittsburg.

YEARS.	Tons.	YEARS.	Tons.	YEARS.	Tons.
1862............	106,486	1866............	128,056	1870............	155,001
1863............	121,455	1867............	151,128	1871............	158,565
1864............	115,450	1868............	128,649	1872............	157,108
1865............	131,196	1869.	145,858	1873............	159,097

Quantities of Coal shipped annually on the Monongahela Slack-water Navigation.

YEARS.	Tons.	YEARS.	Tons.	YEARS.	Tons.
1845............	134,200	1855............	639,360	1864............	1,
1846............	311,156	1856............	855,364	1865............	1,
1847............	385,805	1857............	1,158,989	1866............	1,
1848............	392,774	1858.....	1,097,866	1867............	1,
1849............	398,340	1859............	1,131,467	1868............	1,
1850............	491,918	1860............	1,517,909	1869........ ...	2,
1851...	490,850	1861............	834,630	1870............	2,
1852............	585,293	1862	743,358	1871............	1,
1853....	628,654	1863............	1,134,570	1872............	2,
1854............	693,278			1873.....	2,

Coal and Coke carried on the Pittsburg & Connellsville Railroad.

YEARS.	Tons.	YEARS.	Tons.	YEARS.	Tons.
1859............	11,294	1864............	130,639	1869............	405.236
1860...........	30,073	1865............	159,590	1870............	469,450
1861............	34,435	1866............	256,642	1871............	565.014
1862............	49,626	1867............	301,659	1872............	Not reported.
1863............	88,696	1868............	390,274	1873............	646.374

Statement of Bituminous Coal moved on the Pennsylvania Railroad in 1870 and 1871, and the Quantities purchased for the Company's Use in each Locality, showing, approximately, the Production of each District.

RAILROADS, ETC.	1870.		1871.	
	Tons.	Co.'s Coal.	Tons.	Co.'s Coal.
Huntington & Broad Top Railroad....	351,895	10,000	240,097	6,956
Tyrone & Clearfield Railroad	585,551	24,992	516,736	26,161
Snowshoe Region	70,239	10,000	61,290	14,896
Alleghany Mountain Region........ ..	144,540	5,012	295,306	.....
Pittsburg Region	301,297	214,612	......	.....
Pittsburg & Connellsville Railroad....	87,478	......	......	.....
P. & E. Railroad, etc..................	......	......	12,319	.....
Westmoreland Region........	......	......	570,475	336,207
Points on W. Pa. Railroad............	......	......	142,681	.....
Vicinity of Brinton....................	......	......	356,835	.....
Between Brinton and Pittsburg.......	......	......	217,898	.....
Pitts. & Conn. Railroad, Brinton......	......	......	70,360	12,308
Pitts. & Conn. Coke, Brinton..........	......		163,845	.....
Coal carried as freight............	1,740,580	264,616	2,430.763	396,584
Coal used by the company............	264,616		396,584	
Total............................	2,005,196		2,867,347	

Coal mined by the McIntyre Coal Company at Ralston, Pa., on the Northern Central Railroad.—In 1870, 17,808 tons; in 1871, 106,130 tons; and in 1872, 171,427 tons. Total production for the first three years, 295,365 tons. Production in 1873, 212,462 tons.

Statistics of the Cumberland Coal-Trade, from its Commencement, compiled from Official Sources by C. Slack, Mount Savage, Maryland.—Details of the Production of 1872.

Nos. on Map.	NAME OF COMPANY OR MINE.	To B. & O. R.R. Tons.	To C. & O. Can. Tons.	LOCAL. Tons.	TOTAL. Tons.
	Consolidation Coal Co.	214,445	238,880	32,137	485,462
8	New Central Coal Co.	125,690	147,349	137	273,176
·0, 11	George's Creek Coal and Iron Co.	192,128	41,232	......	233,360
3	American Coal Co.	99,159	127,766	......	226,925
.5, 16	Borden Mining Co.	90,689	114,644	2,947	207,280
12	Maryland Coal Co.	118,155	80,180	108	198,443
25	Hamp. & Balt. Coal Co. (Midl'd)	5,055	2,968	107	184,586
10	" " (National Mine)	2,985	52,066	46	
	" " (Virginia Mines)	121,364	......	......	
1	Franklin Coal Co.	103,600	......	......	103,600
	Virginia Coal and Iron Co.	85,441	......	......	85,441
4	Piedmont Coal and Iron Co.	78,875	......	......	78,785
5	Potomac Coal Co.	72,637	......	......	72,637
	Atlantic & G. Cr. Coal Co.	55,280	......	......	55,280
1½	George's Creek Mining Co.	47,827	......	......	47,827
2	Swanton Mining Co	41,559	......	......	41,559
	Lincoln Coal Co.	17,827	......	......	17,827
14	Midlothian Coal and Iron Co.	10,374	......	......	10,374
	Spruce Hill Coal Co.	......	11,023	325	11,348
	Big Vein Coal Co.	......	......	......	......
3	Barton Coal Co.	......	......	......	......
		1,482,540	816,103	34,807	2,333,450
	Total to Pennsylvania Railroad			......	22,021
					2,355,471
	Total for 1871			......	2,345,153
	Increase for 1872			......	10,318
	RECAPITULATION.				
	By Cumb. & Penn. Railroad to Balt. & Ohio Railroad			1,262,858	
	" " " Ches. & O. Canal			612,587	
	" " " Pennsylvania Railroad			22,021	
	" " " Local			21,098	
					1,918,514
	By Cumberland Branch Road to B. & O. Railroad			22,877	
	" " " C. & O. Canal			203,566	
	" " " Local			3,709	
					230,152
	By Hamp. & Balt. Co. (Va. mines) to B. & O. Railroad				121,364
	By Virginia Coal and Iron Company				85,441
	Total tons in 1872				2,355,471
	1,531 tons gas-coal shipped during the year by canal.				

Coal used in Locomotives by the Four Great Railroads.

Baltimore & Ohio Railroad, 1872	277,194	tons.
Pennsylvania Railroad, 1871	386,584	"
Erie Railway, 1872	325,000	"
New York Central & H. R. Railroad (Albany to Buffalo), 1872	287,000	"
Total	1,275,778	"

Coal used in the Manufacture of Pig-Iron.[1]

Anthracite, 1,197,010 tons pig, at 2 tons	2,394,020
Raw bituminous, 712,500 tons pig, at 2½ tons	1,781,250
Anthracite and bituminous coal used	4,175,270

[1] There were 478,500 tons made with charcoal.

THE CUMBERLAND COAL-TRADE, FROM 1848 TO 1872, INCLUSIVE—TWENTY-FIVE YEARS.

	CUMBERLAND & PENNSYLVANIA RAILROAD.				CUMB. COAL & IRON CO.'S RAILROAD.			G. C. R. R.	HAMP. R. R.	B. & O. R. R.	C. & O. CANAL	PA. R. R.	Aggregate No. of Tons.
	Railroad.	Canal.	Pa. R. R.	Total.	Railroad.	Canal.	Total.	Total.	By B. & O. R. R.	Total.	Total.	Total.	
1848...	86,571	......	....	86,571	43,000	......	43,000	......	......	79,571	......	....	79,571
1849...	63,676	......	....	63,676	78,778	......	78,778	......	......	142,449	......	....	142,449
1850...	73,783	3,167	....	76,950	119,023	875	119,898	......	......	192,806	4,042	....	196,848
1851..	70,893	51,438	....	122,331	103,808	31,540	135,348	......	......	174,701	82,978	....	257,679
1852...	128,534	46,257	....	174,891	139,925	19,862	159,287	......	......	268,459	65,719	....	334,178
1853...	150,381	84,060	....	234,441	155,278	70,535	225,818	78,725	......	376,219	157,760	....	533,979
1854...	148,953	63,731	....	212,684	173,580	92,114	265,694	181,308	......	503,836	155,845	....	659,681
1855...	93,961	77,095	....	171,056	97,710	100,691	198,401	227,425	65,570	478,486	183,786	....	662,272
1856..	86,994	80,387	....	167,381	121,945	105,149	227,094	269,210	42,765	502,330	204,120	....	706,450
1857.	80,743	55,174	....	135,917	88,573	54,000	142,573	252,868	51,628	465,912	116,574	....	582,486
1858...	48,018	166,712	....	214,730	66,009	87,539	153,548	218,318	63,060	395,405	254,251	....	649,656
1859...	48,415	211,639	....	260,054	72,423	86,203	158,626	257,740	47,934	426,512	297,842	....	724,354
1860...	70,669	232,278	....	302,947	80,500	63,600	144,100	289,298	52,564	493,031	295,878	....	788,909
1861...	23,878	68,303	....	92,181	25,983	29,296	55,279	85,554	86,660	172,075	97,599	....	269,674
1862...	71,745	75,206	....	146,951	41,096	23,478	64,574	69,482	86,627	218,950	98,684	....	317,634
1863...	117,796	173,269	....	291,065	111,087	43,523	154,610	266,430	86,240	531,558	216,792	....	748,345
1864...	287,126	194,120	....	481,246	67,676	64,522	132,198	......	44,552	399,354	258,642	....	657,996
1865...	384,297	285,295	....	669,592	104,651	57,907	162,558	......	71,345	560,293	343,202	....	902,495
1866...	592,988	291,019	....	883,957	52,251	52,159	104,410	......	90,964	736,158	343,178	....	1,079,331
1867...	623,031	385,249	....	1,008,280	40,106	72,904	113,010	......	72,532	735,669	458,153	....	1,193,822
1868...	659,115	424,406	....	1,083,521	100,345	57,919	158,264	......	88,658	848,118	482,325	....	1,330,443
1869...	1,016,777	573,243	....	1,590,020	130,017	78,908	208,925	......	88,724	1,230,518	652,151	....	1,882,669
1870...	909,511	520,196	....	1,429,707	[1] 114,404	[1] 83,941	[1] 198,345	[2] 28,035	60,988	1,112,988	604,187	....	1,717,075
1871...	1,247,279	656,085	....	1,903,364	[1] 69,864	[1] 194,254	[1] 264,118	[2] 81,218	96,453	1,494,814	850,339	....	2,345,153
1872...	1,288,956	612,537	22,021	1,918,514	[1] 26,586	[1] 203,666	[1] 230,152	[2] 85,441	121,864	[3]1,517,847	816,108	....	2,355,471
Tons..	8,874,207	5,330,966	22,021	13,727,194	2,303,511	1,673,985	3,977,496	2,885,357	1,163,628	14,191,564	7,040,100	22,021	21,258,685

[1] Cumberland Branch. [2] Virginia Coal and Iron Company.

[3] Includes 42,760 tons used on line of Cumberland & Pennsylvania Railroad and its branches, and at Cumberland and Piedmont; also 277,194 tons used by the Baltimore & Ohio Railroad Company in locomotives, rolling-mills, etc.

NOTE.—The quantity forwarded to market in 1842, the first year of the Cumberland coal-trade, was 1,708 tons; in 1843, the second year, 10,082 tons; in 1844, the third year, 14,890 tons; in 1845, the fourth year, 24,653 tons; in 1846, the fifth year, 29,795 tons; in 1847, the sixth year, 52,490 tons, all of which are included in the above totals.

Statistics of the Coal carried on the New York Canals, derived from the Reports of the Auditor of the Canal Department.[1]

DATE.	Tons going West and North from Tide-water.	Tons arriving at Tide-water.	Tons going East from Buffalo (Ohio-coal).	Total Tons of Coal shipped on the Canals.	Tolls per ton per M. in Mills.	Tolls paid on Coal.
1843	9,738	6,898	......	20,371	9 m.	$22,568
1844	14,089	9,340	8	29,389	"	49,846
1845	18,809	28,899	976	47,655	"	81,016
1846	17,599	9,423	1,643	38,223	1 m.	8,124
1847	32,859	16,290	789	64,378	"	49,697
1848	39,599	16,073	2,450	75,831	"	15,230
1849	37,581	15,127	1,495	70,326	"	13,394
1850	46,739	16,075	3,969	80,197	"	15,940
1851	67,904	13,055	4,230	112,977	"	15,916
1852	69,928	7,411	5,899	145,296	"	19,054
1853	95,338	15,127	10,413	225,517	"	25,153
1854	98,606	42,909	15,546	275,683	"	40,329
1855	95,746	18,086	10,393	290,775	"	40,113
1856	142,693	27,079	9,730	363,348	"	42,079
1857	116,911	14,090	14,094	334,729	"	48,750
1858	144,275	14,736	16,389	335,176	"	32,803
1859	142,496	57,119	35,943	412,075	2 m.	46,297
1860	164,923	72,788	36,072	490,495	"	91,130
1861	170,795	63,808	38,080	542,150	"	112,155
1862	173,381	75,349	28,957	636,730	"	126,116

Statistics of the Coal-Trade on the New York Canals (continued).

Bituminous Coal-Trade on Lake Erie.

The first time that bituminous coal appears as an article of commerce at the Lake ports was in 1829, when the northern division of the Ohio Canal was opened to the edge of the Ohio coal-field, near Akron. From this date until about 1854, when the Cleveland & Pittsburg and Cleveland & Mahoning Railways penetrated the same coal-field, it was brought to Cleveland wholly by canal. The bituminous coal from Mercer County, Pennsylvania, in the Chenango Valley along the eastern line of Ohio, is

[1] The following are the quantities carried annually on these canals from 1834 to 1842, west and north from tide-water, being the whole trade, and the only statistics preserved during that period: 1834, 1,103 tons; 1835, 5,978 tons; 1836, 5,436 tons; 1837, 6,460 tons; 1838, 6,472 tons; 1839, 7,504 tons; 1840, 6,054 tons; 1841, 9,868 tons; and 1842, 7,714 tons: in all, 56,098 tons in nine years.

[2] A very large quantity of coal for the supply of the State of New York, west of the Hudson River, and for shipment from Buffalo and Oswego to the Western States, is carried by railroads, in addition to these shipments by canal.

received and shipped at Erie, in the former State. The two ports of Erie and Cleveland transact substantially all the bituminous coal business of Pennsylvania and Ohio on the Lakes, except the Blossburg coal for blacksmithing, which is shipped from Buffalo and Oswego, and amounted to 108,174 tons in 1872, of which Buffalo had 74,559 tons. The following valuable statistics of the early history of the Western export trade in Pennsylvania and Ohio bituminous coal are from Prof. Raymond's *Engineering and Mining Journal:*

Bituminous Coal received from the Interior at Erie, Cleveland, and Chicago, prior to 1858, *in Tons of* 2,000 *Pounds.*

YEAR.	Cleveland.	Erie.	Chicago.	YEAR.	Cleveland.	Erie.	Chicago.
1829......	708	....	......	1844......	18,901	......	......
1830......	178	....	......	1845......	31,186	15,000	......
1831......	294	....	......	1846......	28,183	27,500	......
1832......	431	....	......	1847......	44,401	51,000	......
1833......	1,719	....	......	1848......	66,351	70,000	......
1834......	3,347	....	......	1849......	66,801	79,618	......
1835......	1,776	....	......	1850......	83,850	57,541	......
1836......	2,944	....	......	1851......	107,135	72,948	......
1837......	6.421	....	......	1852......	137,926	76,650	3,310
1838......	2,496	....	......	1853......	178,915	123,081	2,195
1839......	4,901	....	......	1854......	170,975	95,611	4,627
1840......	6,028	....	......	1855......	299,808	141,184	9,569
1841......	16,744	....	......	1856......	246,995	112,011	9,249
1842......	16,389	....	......	1857......	321,390	126,159	37,337
1843......	13,574	....	......				

The consumption of "block-coal" at the fifty furnaces in the valleys of the Chenango and Mahoning Rivers is estimated at 800,000 tons. This variety is being rapidly exhausted, and already brings an extra price. It is, notwithstanding, shipped largely to other ports on the lake. Large quantities of the ordinary bituminous coal mined in the vicinity of Massillon, and hence called "Massillon coal," are also sold and shipped from Cleveland, and often at very low prices.

The following additional statistics of this coal-trade at Cleveland are from the Reports of the Board of Trade, the first of which was published in 1865. The anthracite coal, which is about 10,000 tons per annum, is omitted in this statement:

Bituminous Coal received and shipped at Cleveland since 1857, *in Tons of* 2,000 *Pounds.*

DATE.	Received by Canal.	Received by Rail.	Total.	Shipped.	Consumed at Cleveland.
1858..........................	78,392	143,875	222,267	129,048	93,219
1859 to 1861 wanting..........	......	....	....	....	....
1862..........................	81,400	265,306	346,706	....	....
1863..........................	137,000	318,445	455,445	....	....
1864 wanting..................	....	....	....	....	....
1865..........................	153,112	307,438	460,550	214,837	245,713
1866..........................	171,569	404.826	576,393	279,840	296,553
1867..........................	125,102	444.914	632,016	324.027	297,989
1868..........................	197,4[illegible]5	547,964	745,439	392,388	353,051
1869..........................	225,401	685.211	910,621	396,067	524,555
1870..........................	120,000	774,000	894,000	482,390	411,610

Coal received at and shipped from Chicago 1865 *to* 1870.

HOW RECEIVED.	RECEIVED AT CHICAGO.					
	1865-'66.	1866-'67.	1867-'68.	1868-'69.	1869.	1870.
By Lake	268,771	385,906	391,318	450,127	510,876	629,560
Illinois & Michigan Central	15,061	23,613	14,576	11,945	8,336	......
Chicago & Northwestern	....	68	1,229	470	....	5,051
Illinois Central	3,630	5,250	3,080	6,019	18,968	8,925
Chicago, Rock Island & Pacific	16,595	11,556	9,959	14,544	16,075	11,730
Chicago, Burlington & Quincy	665	1,084	20	217	117	1,838
Chicago & Alton	19,361	68,836	103,972	106,690	151,490	176,876
Michigan Central	7,880	11,090	3,876	60	20	....
Lake Shore & Michigan Southern	....	3,349	9,233	7,626	366	7,053
Pittsburg, Fort Wayne & Chicago	8	....	11,006	15,121	19,679	55,190
Pittsburg, Columbus & St. Louis	....	....	....	....	71,183	96,309
Columbus, Chicago & Indiana Central	18	490	6,472	46,403	....	....
Total	344,854	496,193	546,206	658,284	799,000	887,474

HOW SHIPPED.	SHIPPED FROM CHICAGO.
	1865-'66.
By Lake	2,234
Illinois & Michigan Central	......
Chicago & Northwestern	13,928
Illinois Central	1,697
Chicago, Rock Island & Pacific	......
Chicago, Burlington & Quincy	3,495
Chicago & Alton	290
Michigan Central	90
Lake Shore & Michigan Southern	460
Pittsburg, Fort Wayne & Chicago	232
Pittsburg, Columbus & St. Louis	......
Columbus, Chicago & Indiana Central	1,070
Total	24,064

YEAR.	Tons received.	Tons shipped.
1871	1,061,472	96,833
1872	1,396,094	177,697

(For the coal-trade of San Francisco, *see* page 575.)

The selling prices of coal, and the cost of mining and transportation, are too fluctuating in America to be entitled to a place in a permanent work like this. For information of this character, the reader is referred to the various commercial newspapers, especially to the following, devoted wholly or chiefly to the subject of coal and the coal-trade:

The Miners' Journal, Pottsville, Pa., Bannan & Ramsey, Publishers. $2.75 per annum, weekly.

Engineering and Mining Journal, New York, R. W. Raymond, Editor. $4 per annum, weekly.

The Coal and Iron Record, New York, Western & Co. Weekly, $3 per annum.

Saward's Coal-Trade Circular, by F. E. Saward, New York; $2.50 per annum, eight pages, weekly, on Wednesday.

The United States Railroad and Mining Register, Philadelphia; weekly, $3 per annum. Edited by J. P. Lesley.

The monthly auction-sales of Scranton coal in New York are the best barometer to indicate the prices of anthracite coal.

COAL PRODUCTION OF THE GLOBE.

From the foregoing statistics the following statement is made of the whole quantity of coal produced in the world, by estimating that mined in countries from which no statistics can be obtained. The area in square miles of the coal-fields is also given, showing, as before remarked, that some of the coal-fields are barren, or nearly so, or situated at too great a distance from market, or of too poor a quality, to be worked advantageously. On the other hand, in other places, as in Belgium, a large number of small coal-seams are found beneath a small surface, and in other localities, as in England, with a small area, the coal-beds are of great size, and occur in large numbers, conveniently near the surface, with all the circumstances favorable to a large production.

COAL-PRODUCING COUNTRIES.	Area in sq. Miles of Coal-fields.	Date.	Tons.	Per cent. Production.
The United States	192,000	1872	41,000,000	18.66
Nova Scotia	18,000	1871	673,242	0.31
Great Britain	11,900	1871	117,352,028	53.41
France	1,800	1867	12,148,223	5.54
Belgium	900	1871	13,671,470	6.23
Prussia	1,800	1869	26,774,368	12.19
Austria	1,800	1862	4,525,783	2.06
Spain	3,000	1869	593,023	.27
Chili, Australia, India, China, etc.	28,800	1872	3,000,000	1.37
Totals	260,000		219,738,147	100.

It is the manifest destiny of America soon to become the greatest coal-producing country of the world.

THE COAL-REGIONS OF AMERICA.

SUPPLEMENT FOR THE YEAR 1874,

CONTAINING INFORMATION COLLECTED SINCE THE PUBLICATION OF THE PREVIOUS EDITIONS OF THIS WORK.

Statistics of Coal mined in Pennsylvania, in 1873.

COUNTIES.	Sent to Market. Tons.	Home Consumption. Tons.	Total Product. Tons.
1. ANTHRACITE.[1]			
Schuylkill	4,252,043	880,000	5,132,043
Northumberland	1,234,070	170,000	1,404,070
Columbia	858,741	25,000	883,741
Dauphin	449,915	30,000	479,915
Wyoming	10,047,241	1,675,000	11,722,241
Lehigh	8,243,168	463,000	8,706,168
Total anthracite	19,585,178	3,243,000	22,828,178

COAL.	Tons.	Totals.
2. SEMI-BITUMINOUS.		
Fall Brook Coal Company, Blossburg, Pa	312,466	
Morris Run Coal Company, "	357,384	
Blossburg Coal Company, "	321,207—	991,057
McIntyre Coal Company, Ralston, Pa	....	212,462
Towanda Coal Company, Towanda, Pa	252,329	
Fall Creek Coal Company, "	85,315—	337,644
Total Northern Pennsylvania	....	1,541,163
Snow-shoe, Centre County, Pa	95,257	
Clearfield, Clearfield County, Pa	612,086	
Broad Top, Huntingdon County, Pa	350,246—	1,057,589
Total semi-bituminous in Pennsylvania[2]	....	2,598,702
3. BITUMINOUS (produced along the lines of the railroads mentioned below).		
Johnstown used in iron-works, etc., estimated	250,000	
Alleghany Mountain region, on Pennsylvania Railroad	220,409	
West Pennsylvania Railroad, " "	259,340	
Southwest Pennsylvania Railroad, " "	255,355	
Westmoreland gas-coal, " "	878,944	
Pittsburg gas-coal, " "	685,611	
Total	2,549,659	

[1] These anthracite statistics are from the *Pottsville Miners' Journal*.

[2] The production of coal in the Cumberland (Maryland) region, in 1873, was 2,674,101 tons, which, added to the above, makes a total production of 5,272,803 tons of semi-bituminous coal mined in the United States.

Statistics of Coal mined in Pennsylvania, in 1873.—(Continued.)

COAL.	Tons.	Totals.
3. BITUMINOUS (produced along the lines of the railroads mentioned below).—*Continued.*		
Carried forward	2,549,659	2,598,703
Philadelphia & Erie Railroad	81,742	
Alleghany Valley Railroad	436,650	
Erie & Pittsburg Railroad (block-coal)	529,496	
Lawrence Railroad	132,118	
Newcastle & Beaver Railroad	815,044	
Jamestown & Franklin Railroad	111,169	
Little Saw-mill Run Railroad	159,057	
Pittsburg & Castle Shanon Railroad	125,109	
Pittsburg & Connellsville Railroad	846,374	
Pittsburg, West Virginia & Charleston Railroad	2,000	
Pittsburg, Cincinnati & St. Louis Railroad	447,855	
Shenango & Alleghany Railroad	99,991	
Wheeling, Pittsburg & Baltimore Railroad	3,783	
Monongahela navigation	2,157,588	
Used by railroads, and not in the above	600,000	
Mined on rivers, and from country pits, not in above	500,000	
Total common bituminous coal		9,096,680
Total of bituminous coal		11,695,383
Add anthracite		22,828,173
Total production in Pennsylvania, in 1873		34,523,560

Production of Coal in the United States, in 1873.

STATES AND TERRITORIES.		Tons.
Pennsylvania, per the preceding statement		34,523,560
Maryland, per official reports of railroad and canal		2,674,100
Virginia, Richmond field, estimated		60,000
West Virginia, estimated		1,000,000
Ohio, from report of Commissioner of Statistics		3,944,340
Eastern Kentucky, estimated		50,000
Western Kentucky, estimated		350,000
Tennessee, from report of Bureau of Agriculture		400,000
Alabama, estimated by a resident mining engineer		60,000
Michigan, estimated		50,000
Indiana, estimated by Dr. E. T. Cox, State Geologist		1,500,000
Illinois, estimated		3,500,000
Iowa, "		350,000
Missouri, "		1,000,000
Kansas, "		50,000
Colorado, Wyoming, Utah, etc., lignite	500,000	1,000,000
Pacific coast, lignite	500,000	
Total		50,512,000

The Several Mining Districts of Hungary, according to the Present Territorial and Political Subdivisions, each produced, in 1872, *the following Quantities of Coal and Brown Coal, which is included in the Table at the Head of Page* 677.

DISTRICTS.	Brown Coal. Tons.	Black Coal. Tons.
1. Neusohler	393,081	....
2. Ofner	342,278	368,961
3. Oravitzaer	678	264,959
4. Zips Fzlemer	11	....
5. Zalalhuaer	176,294	....
6. Agramer	17,747	3,080
Total, as given on page 677	929,979	631,300

Quantities of Coal and Brown Coal produced in Each Province in Austria, in the Years 1871 *and* 1872, *furnished for this Work from Official Sources by William K. von Fritsch, Mining Engineer of Steyr, Austria, the Austrian Centners* (123½ *Pounds*), *being reduced to Tons of* 2,240 *Pounds.*

PROVINCES.	1871.		1872.	
	Brown Coal. Tons.	Black Coal. Tons.	Brown Coal. Tons.	Black Coal. Tons.
Lower Austria	29,916	48,001	54,014	45,282
Upper Austria	258,595	5,651	282,082	1,228
Styria	1,089,878	....	1,285,045	4,984
Carinthia	76,828	....	75,958	....
Carniola	161,678	....	156,871	110
Coast Land	82,759	....	87,657	....
Tyrol	22,478	....	24,540	....
Bohemia	2,288,865	2,478,596	2,744,409	2,858,671
Moravia	108,848 }	1,525,796	115,941	1,411,219
Silesia	167 }	....	280	....
Galicia (Cracow)	5,888	226,940	12,182	265,591
Bukowina	1,653	....	....	....
Dalmatia	4,458	....	7,764	....
Hungary	842,858	607,497	929,979	681,800
Total	4,998,869	4,892,481	5,676,672	4,718,280
Total tons of both kinds	....	9,891,350	....	10,889,952

Coal Production of the Globe.

COUNTRIES.	Years.	Tons.
The United States, per preceding statement	1873	50,512,000
Nova Scotia, from report of Department of Mines.	1873	1,051,567
Great Britain, from Hunt's official "Mineral Statistics"	1872	123,497,316
France, from official report from Paris	1872	15,000,000
Belgium	1872	15,658,948
Germany	1870	28,816,238
Austria, from official Statistical Bureau	1872	10,889,952
Russia, from Vienna Exposition report, area 30,000 square miles	1871	817,000
Spain, by Prof. Gruner, of Paris	1870	414,482
India, 2,004 square miles coal	1868	547,971
New South Wales	1871	790,143
Chili, China, Japan, New Zealand, and all other countries (estimated)	....	1,000,000
Total	....	242,995,617

McKEAN COUNTY (PA.) COAL-FIELD.—(Page 199.)

The division of Northern Pennsylvania into counties, from Susquehanna to Warren, inclusive, happens to correspond with the six coal-basins. The first basin, as shown in the lower rocks, passes through the southwest corner of Susquehanna County, but destitute of coal until it reaches Sullivan. The second basin is that of Towanda, or Barclay, in Bradford County; the third, that of Blossburg, is in Tioga; the fourth is in Potter; the fifth in McKean; and the sixth in Warren. The body of coal in the fifth basin, in the southern part of McKean County, is so large and important, and is situated so near the Buffalo and Rochester markets, that it is entitled to notice, although no coal is as yet mined there or sent to market. In Sargeant Township, at Bishop's Summit, on the head-waters of the Instanter, running into the

Clarion on the south, and on Red Mill Brook, running into Potato Creek and the Alleghany River on the northeast, is a large solid body of several thousand acres of unbroken coal-measures. No other of the coal-basins contains so large a body of coal at its northern extremity as this, owing probably to its being situated on the dividing waters where the work of denudation has been less destructive. An excellent railroad route renders the region accessible by a proposed branch from the Buffalo, New York & Philadelphia Railroad up the valley of Potato Creek, past Smethport, and by Red Mill Brook to Bishop's Summit, the distance being but 108 miles to Buffalo and 150 to Rochester. The valleys of all the streams have been surveyed, but that of Red Mill Brook furnishes the easiest possible ascent of the northern slope in crossing the water-shed, there being none other as good for railroad grades by at least thirty feet per mile.

Through the ridge at Bishop's Summit the coal-basin is continuous; unlike all the other coal-basins in the north, no valley cuts down through it, and all the investigations show that its measures are unbroken by any intervening axis to throw them up and squeeze out the coal-veins. On the contrary, the high ground lies directly across the body of the coal-canoe, which has its prow far to the north, on Red Mill Brook. This can be said of no other prong of the great bituminous coal-field; all the others that reach the water-shed, drained by the Upper Alleghany, are interrupted by a secondary axis that either entirely cuts them off or throws the measures up so near the surface as greatly to reduce their value at that point, and leaves their continuation northward a series of detached and much-broken basins. Partial explorations by borings, trial-pits, and outcrop openings, at points widely separated on the Wernwag lands, on Bishop's Summit, have developed several coal-beds of from 3½ to 4 and 5 feet in thickness. Analyses and practical tests of considerable quantities of this coal, under stationary and locomotive boilers, indicate that it is a good quality of bituminous coal for gas, with excellent steam-generating qualities. No other county in Northern Pennsylvania, not even Tioga, contains so much coal as McKean. A large company, composed of Buffalo capitalists and others, called "The Buffalo Coal Company," has just been organized for the development of this region.

MISSOURI.—(PAGE 477.)

FROM the report of G. C. Broadhead, late Assistant and now State Geologist on the new survey in progress in this State, the following additional facts are derived:[1] The coal-measures of Missouri comprise an area of about 22,955 square miles (by a recent careful revision, 23,100 square miles), including 8,406 square miles of upper barren measures, about 2,000 of exposed middle, and 12,420 of exposed lower; also including 160 square miles in St. Louis County, eight in St. Charles, and a few others in Mont-

[1] "Geological Survey of Missouri," Ralph Pumpelly, Director. "Preliminary Report on the Iron-Ores and Coal-Fields of Missouri, from the Field-Work of 1872." Pp. 655, large 8vo, with Atlas. New York, 1873. Also "Report" of same Survey, 1855–1871. Pp. 323. 1873.

MAP OF THE COAL-FIELD OF MISSOURI.

Reduced from the State Geological Map of G. C. Broadhead, Assistant State Geologist. Published with Pumpelly's Report, 1873.

gomery, Lincoln, and Warren. In Missouri, all beds over 18 inches thick are considered workable coals, and the estimated area, where such may be reached within 200 feet of the surface, is about 7,000 square miles.

The lower coal-measures are 250 to 300 feet thick, and contain five workable coal-seams from 1¼ to 4½ feet thick, and thin seams 6 to 11 inches, with several still smaller, in all 18½ feet of coal. Northwestward from these are the less important middle coal-measures, 324 feet thick, with two workable seams 21 and 24 inches, one of one foot, and six others too thin to work, in all about seven feet of coal. Farther northwestward are the upper barren coal-measures, 1,317 feet thick, with two seams of coal one foot thick, with some other very thin seams, mere streaks, in all two feet. The total thickness of the coal-measures is 1,900 feet, and of the coal-seams 24½ feet.

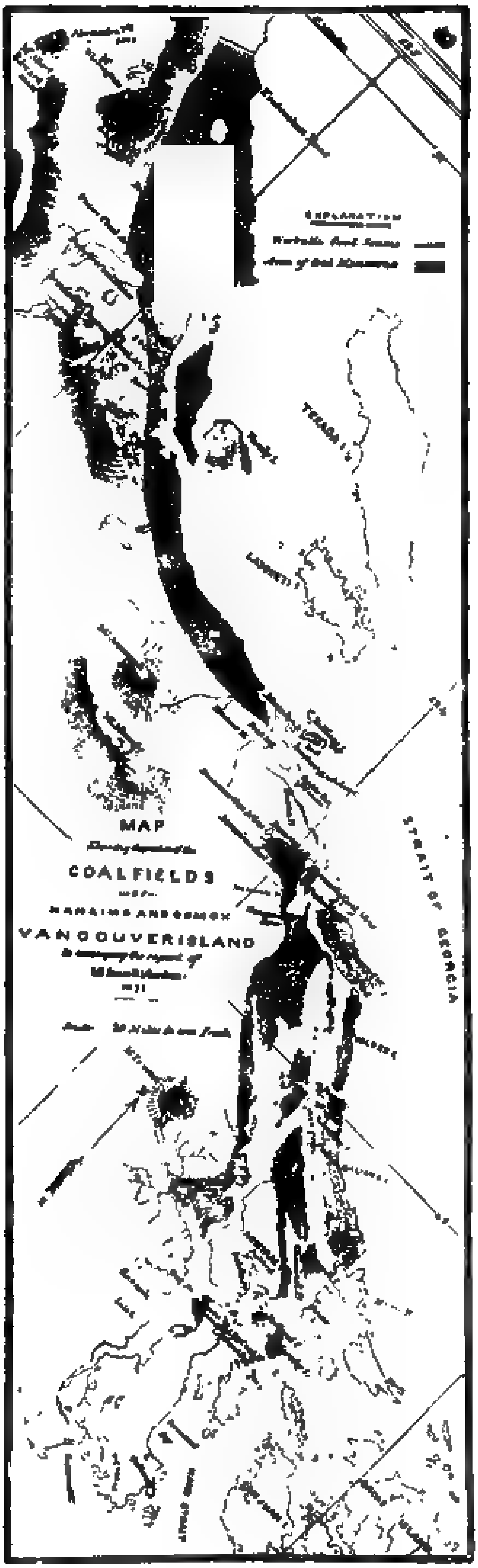
The boundary between the middle and lower coal is not well defined, but is limited by a thick-bedded, coarse, micaceous sandstone, sometimes not of great extent, at other times of great thickness. We suppose it to enter the State in the west part of Bates County, and to pass thence *via* Butler to Chilhowee, in Johnson County; thence northwardly, four miles west of Warrensburg, to four miles east of Aullville, Lafayette County; thence irregularly meandering through Lafayette County, crossing the Missouri River, passing to ten miles east of Carrollton, Carrollton County; thence to the southeast corner of Livingston County, from which point it bears northeast to the centre of Linn County, and thence northward. The southern and eastern boundary of the lower coal-measures is as follows (through Barton, Bates, Vernon, and St. Clair, the boundary has not yet been well defined): entering the State in Barton, it passes northeast through the eastern part of Vernon; it enters St. Clair about one-half way up on its western line; thence meanders eastward to a point a few miles north of Osceola; thence northward to within eight miles of Clinton, Henry County; thence northeast to the east line of Henry County; thence northwardly, with occasional variations of sandstones, as much as eight miles east to Brownsville, Saline County; thence northeastward to Marshall; and thence to Miami. On the north side of the river it passes eastward, from a point opposite Arrow Rock, to the east line of Howard County; thence in a meandering course, *via* Columbia, Boone County, New Bloomfield and Fulton, Callaway County, to the northeast corner of Callaway; thence northeastwardly to a point three miles west of the northeast corner of Montgomery County; thence northwest to near the mouth of Lick Creek, Ralls County; thence southwest to Mexico, Audrain County; thence to the northwest corner of Monroe County; thence irregularly trending northward to the northwest corner of Knox County; thence to a point on the north line of Lewis County, about twelve miles west of the Mississippi River; thence northwardly to the Desmoines River, on the north line of the State of Missouri. East of this are small outliers in Montgomery, Warren, Lincoln, and St. Louis Counties, and perhaps others in Southwest Missouri.

NORTH CAROLINA.—(Page 528.)

The coal-field of Deep River has been worked by a shaft 480 feet deep at a place called Egypt. The coal-seam consists of two parts, the upper being two and the lower four feet thick, separated by 18 inches of bituminous shale, containing 20 per cent. of iron-ore. The coal is a rich bituminous variety, and makes a very superior coke. The mine was opened in 1856 by the Governor's Creek Company, but the shaft, for want of a market for the coal, was soon allowed to fill up with water. In 1862 it was worked by the Confederate Government, and 30,000 tons of coal were taken out in one year. After the war it was worked by a party from Philadelphia, but is now (1874) full of water. It has the fixtures of a first-class colliery, and is connected by a railroad with Raleigh and Norfolk on the north and Fayetteville on the south. East of this mine is a slope at Farmville, which was worked until it was abandoned on account of a fault. East of Farmville is Hornsville Slope, which has upon it a full outcrop of the four-foot seam. The Egypt shaft, and the two slopes mentioned at Farmville and Hornsville, are the only points at which the Deep River coal-field has been worked. West of Egypt shaft the Taylor place is said to be a valuable coal property, and ten miles farther up the river are three or four other good properties; but it will be seen that there is no production of coal at present in any part of the coal-fields of North Carolina.

VANCOUVER ISLAND COAL-FIELD.—(Page 572.)

The coal-field of Vancouver Island consists of a narrow trough, the southwest side of which only occupies the northeastern shore of the island, the remainder of the field extending beneath the waters of the Strait of Georgia. The crystalline rocks, coming apparently from beneath it in Lasqueti, Texada, and other islands, and on the main-land beyond, are evidently the boundary of the trough on the northeast side. Its boundary on the southwest side, on Vancouver Island, is manifestly a range of very bold mountains of the crystalline series, which run nearly parallel with the coast, having many points from 4,000 to 7,000 feet above the sea. The field of coal extends, with some interruptions, from a point about fifteen miles north of Victoria, on the southeast, to the vicinity of Cape Mudge on the northwest, with a length of about 130 miles, and is quite narrow, the greatest width being thirteen miles at the Beaufort claim. Coal-beds are exposed in upward of a dozen localities, and in five of them claims have been laid before the Government. The general surface of the coal-field is rolling, with no elevations rising to a greater height than 800 to 1,000 feet, and in others it is comparatively level. It is mostly covered with forest, but in some parts presents a prairie or park-like aspect, with grass-covered ground, studded with single trees or clumps of them. It has a good soil, offers great encouragement to agricultural industry, and may hereafter be thickly settled.


EXPLANATION
MAP
COALFIELDS
VANCOUVER ISLAND
STRAIT OF GEORGIA

NANAIMO.—For convenience it may be divided into two districts or basins—that of Nanaimo, including some adjacent smaller islands, about seventy miles from Victoria, and the other at Comox Harbor, about seventy miles farther northwest, both on the southwest side of the Strait of Georgia. The natural exposures of coal in the Comox basin are much the best, but the Nanaimo district is at present much the more important, coal having been worked there for more than twenty years. The sales in the last ten years have been 300,000 tons. The production in 1860 was 14,000 tons, of which 6,655 were sold at San Francisco. That of 1869 was 35,802 tons, of which 14,880 went to San Francisco. In 1870, 29,863 tons were mined; and in 1871, 45,000 tons, of which 15,621 went to San Francisco. The production of 1872 and 1873 is not reported; but as the sales at San Francisco in 1872 were 26,008 tons, and in 1873 31,435, tons, there was, no doubt, an increased production. It is probably now the most productive coal-region on the Pacific coast, except, perhaps, Coos Bay. The coal is supplied to the town of Victoria and to steamers calling at that place on their way to San Francisco, Portland in Oregon, and Honolulu in the Sandwich Islands. There is another coal company in the province, from which no returns have been received.

The area of the Nanaimo field is above ninety square miles, extending about sixteen miles in length, from the Dunsmuir claim to the end of Gabriola Island, with an average breadth of about six miles. In the remaining part of the basin to the southeast, no important coal-seam has yet been met with. But little is known, however, as to that region, and there is every probability of the same seams extending into it. The details of the structure have not been ascertained, and the numerous undulations in the Nanaimo coal-field make it difficult to estimate the total volume of the coal-bearing rocks; but for the present it may be safe to suppose that the total thickness of the measures will prove to be at least 2,500 feet.

The main working of the Vancouver's Island Coal Company is at Nanaimo, on a six-foot seam, but of varying thickness, from 2½ to 6 feet. The coal is clean and hard, holding thin leaves of carbonate of lime in the cleavage-joints. The analysis of this coal by Dr. T. Sterry Hunt shows 51.45 of fixed carbon, 38.40 of volatile matter (how much of this is water not being stated), and 10.15 of ashes. Another bed of coal occurs 140 feet below this, associated with two or three feet of shale, in all seven feet, the thickness of both coal and shale being very irregular. The upper seam is worked on the slope, north 54 east, with a very regular inclination of 16° for the first 350 feet, increasing to 70° or 80° in the succeeding 300 feet. The bed then suddenly rises and dips southwesterly at an angle of 20°.

The same company have a coal-mine on Newcastle Island, about two miles north of Nanaimo. Here there are two beds of coal, one from 3½ to 4 feet, and the other, 57 feet lower, from 3 to 4 feet thick, of clean, hard coal. Both of these seams have been mined, but only the lower one is now in actual working. Dr. Hunt's analysis of it shows 52.57 fixed carbon, 35.49 volatile, and 11.94 of ashes. Schooners and steamers are supplied

with coal at this wharf, as well as at Nanaimo. The northern extremity of Newcastle Island presents bold cliffs to the water, which rise to the height of 100 or 150 feet in some places, and are perpendicular, or even overhanging. These are composed of coarse conglomerate rock, in which rounded masses of various sizes occur up to a foot in diameter, consisting of diorite, quartzite, and other hard materials derived from the crystalline series.

A number of smaller islands in this vicinity must be considered as a part of the Nanaimo coal-basin, especially Gabriola Island, ten miles long and three miles wide, east of Newcastle, and two other long, narrow islands, farther southeast, called Valdes and Galiano. All these appear to be a continuation of the same coal-bearing rocks which characterize this area as far at least as Montague Harbor, which is near the south end of Galiano.

There are also quite a number of other little islands farther southeast in this strait, displaying sand-shales belonging to the coal series. Among these are Thetis, Kuper, and Saltsprings Island, as well as the smaller ones called Indian, Secretary Reed, and Hall, having a range parallel with Valdes and Galiano, with numerous undulations of the strata, the dip changing continually both in direction and amount. Also southward of Saltsprings, or Admiralty Island, are situated Moresby, Portland, and Coal Island, all formed of the coal-bearing series. These, being all north of the Haro Strait, belong, like Vancouver Island, to the British Government.

COMOX.—The portion of the coal-field called Comox basin, is about 64 miles long, from Cape Mudge to Northwest Bay, and its greatest width 18 miles at the Beaufort claim. The most promising portion is from Kooshooshun Point to Qualicum River, which may be safely called 40 miles long, with an average breadth of over 7 miles, and containing about 300 square miles. This portion of the field is separated from that of Nanaimo by 14 miles of the crystalline series, besides a space of 20 miles, in which no exposures of rock are seen, showing that the general trough is separated into two distinct basins. In this basin coal-seams are exposed, and claims have been laid before the Government by different parties. The most instructive exposure is on the claim of the Union Coal Company, five miles from the shore, on the southwest side of Comox Harbor. Here are four coal-beds, all of them of unusual size—No. 1, or the lowest, being 10 feet thick, without observed impurities; No. 2, only 8 feet higher, is 6 feet thick, apparently clean and of good quality; No. 3 is 10 feet higher, and 5 feet 4 inches thick, apparently all of good quality; No. 4, 15 feet higher, is 4 feet 6 inches thick, of black and shining coal, apparently clean and free from slate. This extraordinary section shows, in a total thickness of 53 feet 10 inches of strata, 25 feet 10 inches of good coal, or nearly one-half of the whole, in beds of good size for working. The intermediate layers are brown and gray sandstone, and the dip of the measures is north 32° east 11°. The section was taken in an almost perpendicular cliff, which rises on the north side of a small brook, tributary to the Puntledge River, afford-

ing the best opportunity for a correct examination. One of these coal-beds is exposed at another point down the stream, showing an apparent regularity for at least that distance.

There are reports of coal-beds found in other localities, as much as 16 miles farther northwest, along the coast of Vancouver Island. South of the Union claim is the Beaufort coal-mine, a little over five miles from the coast. Here, on Bradley's Creek, is a seam of good hard coal measuring 8 feet 2 inches, and there is a report of one on Trent River 9 feet thick. The Bayne's Sound mine, farther southeast, shows two coal-beds 60 feet apart, the upper one 5 feet 10 inches, of clean and hard coal, and the other from 5 to 7 feet thick. On Denman's Island, lying on the northeast side of Bayne's Sound, is a continuous exposure for 10 miles of the coal-bearing rocks.

None of the coal-beds in the Comox basin have been opened for profitable working. For the facilities of trade, Comox Harbor would afford excellent accommodations to the Union mine, five miles distant, and 500 feet above the sea; and for the Beaufort mine, seven miles distant, and 700 feet above the sea. Bayne's Sound mine is three miles from Fanny Bay and eight miles from Deep Bay, both being small but safe harbors. All the approaches of the harbors named, as well as the harbors themselves, have a depth of from 5 to 12 fathoms at low water.

Dr. Hunt reports that two specimens of Bayne's Sound coal in the Comox basin, and one from Nanaimo, yield a firm coke. The following are the analyses:

COAL.	Carbon.	Volatile.	Ash.
Bayne's Sound, Upper Seam	57.48	29.10	13.42
" " Lower "	64.70	29.55	5.75
Nanaimo, Upper Seam	51.45	38.40	10.15

The first of the above yields "a firm, dense, shining coke," and the others "a firm coke." There is also a report of an analysis by Dr. Hunt of coal from Nicola River, on the main-land in British America, showing 74.58 carbon; 21.51 volatile; 3.91 ash, and producing "a firm, dense coke." This, containing so large an amount of carbon, must be an unusually good quality for coal of the Pacific coast.

The foregoing account has been compiled from the "Report of the Progress of the Geological Survey of Canada for 1871–'72," the examination of Vancouver Island having been made by James Richardson for Alfred R. C. Selwyn, the director of the survey. The map attached to the report is reproduced on a reduced scale. The few imperfect fossils collected belong to a flora, about which there has been some controversy as to whether they are Cretaceous or Tertiary.

ORIGIN AND GEOLOGICAL AGE OF THE WESTERN LIGNITES. —(PAGE 529.)

FROM the irregular thickness, the want of continuity, and the supposed absence of roots in the under-clays, some geologists were at first inclined to believe that the Western lignites were produced from vegetable material drifted together, and not grown on the spot and submerged, as is the case with carboniferous coal. Such an opinion must have been founded on very imperfect observations. The idea that the clay-beds under the lignite coal are without roots, is without any foundation whatever. On the contrary, Prof. Lesquereux says the under-clay is most generally so full of rootlets that it is impossible to study their species on account of their enormous quantity and superposition. (*See American Journal of Science and Arts*, January, 1874.) Those roots are, he says, rather small, filiform, like bundles of small cords heaped and pressed together, and of the same kind as those now seen floating in rivulets, or in swamps, where they indefinitely divide into filaments. Of course, in some cases the heaping of the vegetable matter constituting the lignite may have begun at the surface of waters, or swamps, whose bottom had already been covered with a bed of clay, and the floating carpet of the surface has been afterward depressed by its weight to the clay-bed, which, in such case, would not contain roots. The formation of peat should be studied in order to understand that of coal.

No doubt, some beds of lignite are formed from drifted wood, like those at the mouth of the Rhone in France, and consequently they contain half their weight of earthy or sandy matter. But how, he asks, could the material constituting beds of very pure lignite, nine to fifteen feet thick, have been drifted without containing any particles of foreign matter? Some of these lignites have a proportion of ashes only equal to, or even less than, wood, and in extent they were originally at least as extensive, and the beds are as large, as those of the Carboniferous formation. There is no doubt that the methods of formation of the lignite and of the true coal were the same. Prof. Meek, also, and all our other geologists who have examined them personally, agree that the Wyoming and Utah coals give every evidence of having been formed by the growth of vegetation on the spot.

The age of our Western lignites is a fruitful subject on which our geologists will have occasion to work for years in the collection of facts. Prof. Hayden, in his Third Annual Report for the Year 1869, pronounced all these Western coals to be Tertiary. In the Fourth and Fifth Reports for 1870 and 1871, Prof. Meek's paleontology proved them to be Cretaceous. On the faith of these reports, the writer, in his "Coal Regions of America," written at that time, gave them the title of "Cretaceous Coals." But in later reports, Prof. Lesquereux, after personal examination, in 1872 and 1873, arrives at the conclusion that the Tertiary age of the plants, and consequently of the coal formed of those plants, admits of no doubt. He thinks the lower lignites are Eocene; the upper ones, those of Carbon and Evanston, he considers Miocene; and above this

the formations containing bituminous shale, sometimes called coal, are Pliocene. Other geologists, familiar with the subject, think the lowest beds, as at Bear River and Coalville, Utah, and possibly some of the beds lowest in New Mexico, are Cretaceous; but they admit that the group passes up quickly into Tertiary. (*See* Prof. Lesquereux's articles on this subject in *American Journal of Science and Arts* for December, 1873, and June, 1874, and in Hayden's Reports.) On the other hand, Prof. J. S. Newberry contends that all the lignites of New Mexico are Cretaceous, and that, whether the great lignite deposit of Colorado should be considered Tertiary or Cretaceous, he thinks it is, perhaps, not yet possible to decide. (*See* his articles in *American Journal of Science and Arts* for April, 1874, and in Hayden's Reports.)

COAL-FIELDS OF BRAZIL.

There are three coal-basins of the Carboniferous age in the extreme southern portion of Brazil, of which the following information is derived from Prof. Charles Frederick Hartt's "Geology of Brazil," 1870: The coal-basin of the river Jaguarao is situated in the southern part of the province of Rio Grande do Sul, between lat. 31° and 32° south and long. 324° and 325° (French meridian), in the valley of the Jaguarao and its tributaries, the Candiota and Jaguarao-chico. It covers an area of about fifty miles by thirty, its greatest diameter being from north to south. The coal-strata are exposed in an elevated escarpment on the banks of the river Candiota, at a place called Serra Gartida, of which there is a handsome engraving forming the frontispiece of Prof. Hartt's work. The section is a very extraordinary one: the lower bed contains 25 feet of good coal of homogeneous character, of a good quality for steam and gas. Above this, and separated by 9 feet of clay, is another coal-bed, 17 feet thick, which has been used on the steamers, and served every purpose of a steam-fuel, and in various other ways, with marked success. Above this, and separated by a parting of blue clay, is a bed of 11 feet of good coal. Above this are a fourth and a fifth bed of three feet and nine feet of coal, of a quality inferior to the others. The fossil plants in the underlying shale determine the geological age of the formation to be Carboniferous. The situation of the beds affords good facilities for working the coal in almost all parts of the basins. Mr. Nathaniel Plant, from whom the account was derived, also describes a second coal-basin exposed in the valley of one of the tributaries of the Rio Jacuahy, called Sao Sepé, in lat. 30° 20′, long. 53° 30′, showing two beds of coal, one 14 and the other 7 feet in thickness, and with an area of about 15 miles. Near the Sao Jeronymo, on the banks of the Jacuahy, is a third coal-basin, in lat. 30°, long. 51° 30′. In the shafts of the mines, at a depth of 57 feet, is a bed of 6 feet of highly-bituminous coal, with several other beds of from 2 to 6 feet in a depth of 183 feet. The engineer of the Rio de Janeiro Gas Company makes a flattering report on the qualities of the Candiota coal, or that of the basin first described above.

Prof. Hartt says there is no question as to the age of the formation, the fossil plants being of the ordinary coal-measure type. The fauna of the carboniferous rocks of Bolivia and Peru, and of the Amazon, indicate that these also are of coal-measure age, and not sub-carboniferous.

NOVA SCOTIA COAL-REGION.—(PAGE 596.)

THE coal-trade of Nova Scotia, in 1873, amounted to 1,051,467 tons, having doubled since 1869. All the coal of the district is subject to a royalty to the government of ten cents per ton of 2,240 lbs., and by this means much more accurate statistics of the production can be obtained than from any other region. Geographically, the name Nova Scotia only applies to the peninsula; but the island of Cape Breton, separated from the mainland by the strait of Canso, is now the more important coal-region. As it was long ago annexed to the province of Nova Scotia as one of its counties, the latter name properly applies to both districts as one political division or province.

In 1825, George IV. granted all the mines and minerals of Nova Scotia to his brother, the Duke of York, who transferred them to the General Mining Association, who held the monopoly until December 31, 1857. By an arrangement made at that time with the Provincial Government, this association surrendered their claim to all the mines and minerals, except coal, within certain defined limits, containing forty-two square miles, in five separate tracts, and on which they pay the same royalty. Two of these tracts are in Nova Scotia proper. Leases on the most liberal terms are now granted by the government to all persons desirous of exploring for coal, and to enter into the business of mining. Some twenty-five mines are now worked, but the largest portion of the coal is produced from the Acadia, Albion, Intercolonial, and the Nova Scotia mines in Pictou County, in Nova Scotia proper; and at the Sydney, Reserve, Lingan, International, Gowrie, Caledonia, and Block-House mines on the island of Cape Breton.

Mr. Richard Brown has been the general manager of the General Mining Association of Nova Scotia since the year 1826, and has published a small work giving a very interesting and excellent account of the coal-fields of Cape Breton, and the various mines that have been opened, with a full history of the coal-trade of the island.[1] It is an eminently practical work, containing the very kind of information which business-men, interested in that part of the Nova Scotia region, would wish to have. In giving the area of the coal-fields of Nova Scotia and Cape Breton, they may be said in general terms to contain 18,000 square miles, but this is the whole extent of the carboniferous formation. The productive coal-area, as in other countries, is very much less. Mr. Brown describes in detail each of the tracts of land on which coal has been discovered and mines opened in Cape Breton, with the number of acres, and even the number of tons of unmined

[1] "The Coal-Fields and Coal-Trade of the Island of Cape Breton," by Richard Brown. London: Sampson Low, Marston, Low & Searle, 1871. 8vo, pp. 166, with Maps and Illustrations.

coal in each, with accuracy. Those interested in any of these coal-mines are referred to the following tabular statement made up from Mr. Brown's book. In making this estimate he assumes that each acre of coal, one foot in thickness, contains 1,500 tons, taking the average specific gravity at 1.250, which is certainly a liberal basis, as 1,000 tons to the foot is the more usual rate for estimating coal in the ground:

Account of the Collieries in Cape Breton, showing the Quantity of Coal in the Ground.

NAME.	Tons.	NAME.	Tons.
1. South Head (50 acres)	262,500	12. Collins	750,000
2. Tracey	3,520,000	13. Mathewson	....
3. Gowrie, Cow Bay	11,872,000	14. Black Rock	2,700,000
4. Block House	9,750,000	15 New Campbelton	9,000,000
5. Acadia	....	16. Chimney Corner	....
6. Clyde	12,500,000	17. Broad Cove (small)	....
7. Caledonia	25,605,000	18. Mabon Area	27,000,000
8. Glace Bay	43,900,000	19. Port Hood (small)	....
9. International	47,600.000	20. Richmond	....
10. Victoria	55,640,000	21. Sea Coal Bay	....
11. Inghabom (20 acres)	....	22. Glasgow	9,683,000
Total new mines			259,782,500
Coal in the lands of the General Mining Association			601,587,875
Total coal in Cape Breton			861,320,375

This does not include Nova Scotia proper.

The acreage of the coal-areas of the General Mining Association amounts to 31,000, of which 9,600 acres are under the sea. But, of the 601,587,875 tons of coal, 60 per cent., or 362,255,000 tons, is contained in these submarine areas, and only 239,332,875 tons is on the main-land.

Those familiar with the coal-mining business will find in the foregoing statements data from which to make the proper allowance in calculating the probable actual future production of this coal-field.

The Sydney mines have a great advantage in being situated near the mouth of the harbor. Many of the other localities are in exposed situations, where shipments can only be made in fine weather, with an off-shore wind.

The coal-field of Sydney, the most extensive and, it may be safely asserted, the most valuable in the province of Nova Scotia, Mr. Brown says, is a tract of country extending a distance of 31 miles along the north coast of the island of Cape Breton, containing an area of about 200 square miles, indented by several bays and harbors. The coast consists of cliffs from 20 to 100 feet high, exposing sections of the coal-measures, from which the land rises gradually toward the interior, rarely attaining a greater elevation than 150 feet at a distance of one mile from the shore. These cliffs, exposed to the abrading action of the surf, are gradually but steadily wearing away; sometimes large masses, being undermined, slip off and become detached. In former times large quantities of coal were stolen by vessels, being picked up on the beach after being mined out by this natural process. Mr. Brown says, if not arrested by artificial means, in the course of

time the whole of the coal-lands will become the prey of the ocean. But, if the new impulse given to the coal-trade within the last two years should continue, it seems more likely that the coal of Cape Breton will all be taken care of, and applied to the supply of human wants before it is destroyed by the slower process of Nature.

The several small coal-basins, of which Mr. Brown gives us the quantities, are situated, as shown on his map, like a number of prows of vessels sticking in the cliffs along the coast, the remainder of the hulls having been washed away. It is said that the other extremities of these synclinal basins are to be found on the coast of Newfoundland. It is evident that the good and valuable coal-properties are few in number, and many of them quite small in extent, sometimes only the very point of the basin alone being left, containing a few acres. This, however, only increases the value of the larger coal-areas. Too much coal is good for the country, but it is often ruinous to the profits of the producer. Judging from the prices paid for Nova Scotia coal in 1873, there must have been a very handsome profit on the business.

On old geological maps, Prince Edward's Island is represented as underlaid with coal. But it is covered with new red sandstone, and is thought by Dr. Dawson, who lately explored it, to contain no coal within a depth possible for mining.

There are thin seams of coal in Newfoundland similar to those in New Brunswick.

THE BRANDON LIGNITE IN VERMONT.[1]

THE rocks of Vermont whose ages are determined by their embedded fossils, are of Silurian and Devonian age, too old to contain workable beds of coal, and were deposited long before the earth was in a condition to sustain the luxuriant growth of vegetation requisite for the production of the immense carboniferous deposits existing in the coal-measures. But persons unacquainted with geology, and perhaps regarding the occurrence of coal as accidental and governed by no fixed laws, have vainly sought for it among the Silurian rocks of the Champlain Valley, confiding more in the evidence exhibited upon the glazed surface of the black slate than in the well-settled facts of science. Disappointment must follow all such unwise adventures.

From the preceding remarks it may be inferred that nothing analogous to coal exists in the State; but such is not the case. Carbonaceous matter, capable of sustaining combustion and emitting heat, is found in the Tertiary deposits of Western Vermont. Brown coal, embracing lignite, is found quite abundantly at Brandon, and, we doubt not, may exist in other places associated with the white clays that overlie the beds of hematite. It is not found in beds, but in upright masses that extend down and cut oblique-

[1] From the "Report of the Geology of Vermont," by Profs. Hitchcock and Hager. 1861.

ly through beds of kaolin. There are two localities of it in Brandon, about sixty rods apart. The larger of these masses, situated contiguous to the ore-bed of the Brandon Iron and Car-wheel Company, having an area of about twenty-five feet square, has been penetrated to a depth of eighty feet perpendicular, and the coal removed and used as fuel for driving the engine to drain the mine and raise the ore. This coal is of a dark-brown color, and is apparently composed of drift-wood and other vegetable matter, that have been promiscuously thrown together at a period comparatively not very remote. The woody texture is plainly to be seen in many of the specimens, and the outlines of many fragments of trees are often well defined. Fruits of various kinds are quite common in the larger bed; but, in the smaller one, no traces of them are to be found. Another noticeable fact in this connection is, that the fruits are found to be different at different depths of the bed. The lignite, upon exposure, turns to a darker color and becomes harder, and resembles more closely bituminous coal than when first taken from the mine. It burns readily, with a yellow flame, emitting no sulphurous or bituminous odor, and produces about the same amount of ashes that is obtained from wood. From an analysis by John H. Blake, Esq., of Boston, one of the proprietors of the ore-bed, this brown coal is found to contain 4.50 of volatile matter, 93.50 of carbon, and 2 per cent. of ash. Not a trace of sulphur is to be found in any of it. In some of the specimens, small, angular fragments of quartz are quite abundant; but the above analysis was not determined from specimens containing that impurity. For several years it has furnished the fuel for raising the ore and driving all the machinery.

The rock upon which the beds of iron-ore repose is the same ferruginous limestone everywhere found in the State beneath hematite. Immediately upon the limestone, which in this mine is occasionally very silicious, there is found a bed of ochre, from six to twenty feet thick. Next above the ochre, and nearly conformable with the limestone beneath, is found an inexhaustible supply of the valuable variety of iron-ore known by the name of brown hematite. It has a variable thickness and an irregular outline. The main bed is known to be 600 feet in length, over 100 in width in some places, and it has been penetrated to the depth of 104 feet. The ore is of a superior quality, and the iron made from it remarkably tough.

Next above the hematite is found the bed of kaolin or white clay, which is quite extensive. In this bed of kaolin, which comes to the surface in several places, is the mass of lignite or brown coal before described, about 25 feet square, standing in a perpendicular column, and extending down obliquely through the kaolin, which has a dip of 40°.

In a southerly direction from the beds just described, and not more than sixty rods distant, is located the Forestdale or Blake ore-bed. In this there is the same sequence of ochre, or kaolin, etc., that exists in the former bed; and the dip and appearance of the bed-rock beneath both are similar. In the midst of the kaolin is a mass of brown coal closely resembling that found in the northern bed, but not so extensive a deposit. To

describe these beds, and the order of their recurrence, would in substance be a repetition of what has already been said respecting the northern bed.

Near Pine Grove, in Cumberland County, Pa., in 1864, a mass of lignite was penetrated in sinking a shaft in a bed of hematite iron-ore.

WEIGHTS AND MEASURES OF COAL.

United States.—By the tariff act of 1872, coal is to be computed for the purpose of collecting duties[1] at 28 bushels to a ton, 80 pounds to a bushel, or 2,240 pounds to a ton. In Pennsylvania, by the act of 1834, 2,000 lbs. avoirdupois make one ton. Other laws in this State recognize the same weight. Seventy-six pounds to a bushel in Alleghany County.

Great Britain.—1 English ton = 2,240 lbs.; 1 cwt. = 112 lbs.; 1 stone = 14 lbs. By an act of Parliament passed in 1835, all local and customary measures are abolished, and all articles, except gold, diamonds, etc., shall be sold by standard avoirdupois weight—a most excellent law, which is much needed in the United States.

France.—1 metrical tonne = 1,000 kilogrammes, or 2,204.86 lbs.; 1 kilogramme = 2.20486 lbs., English, or 2 lbs. 3 oz. 4½ dr.

Belgium has adopted the French system of weights and measures, which is no doubt the best in the world.

Austria.—The centner, quintal, or cwt. of Austria or Vienna = 123½ lbs., English, or 18.14 centners to 1 ton, English.

Spain.—1 quintal of Asturias, by which coal is sold, equals 155 lbs., or 14.45 quintals to 1 ton, English.

Russia.—1 pood = 36 lbs., or 62.22 poods to 1 ton, English.

[1] The duty is 75 cents per ton, and 40 cents for slack or culm, such as will pass through a half-inch screen. But coal-stores of American vessels, if not unloaded, are free. Anthracite coal is also free of duty.

INDEX.

From Prof. J. S. NEWBERRY, *State Geologist of Ohio, and Professor of Geology and Paleontology in Columbia College School of Mines, New York.*

"'The Coal-Regions of America' is an excellent book. It does the author great credit, and furnishes a vast amount of new and accurate information in regard to the greatest of our industries, and the source from which our national wealth must come. I am sure that it will prove indispensable to a very large number of our scientific and business men. A great amount of conscientious labor has been bestowed upon it. I have read it with really great interest and pleasure, and it will be of very great service to me."

From Prof. F. V. HAYDEN, *United States Geologist.*

"Mr. Macfarlane's excellent work, 'The Coal-Regions of America,' seems thorough and exhaustive, giving a vast amount of practical as well as scientific information in a comparatively small compass. The volume fills a place in our scientific literature not occupied by any other work on that subject. I have read the book with great interest and profit."

From Prof. JAMES M. SAFFORD, *State Geologist of Tennessee.*

"I am greatly pleased with the work, which is highly interesting and very valuable. The maps and illustrations show that no expense has been spared to make the volume complete. The author has done a good work."

From Prof. GEORGE H. COOK, *State Geologist of New Jersey, and Professor of Geology in Rutgers College, New Brunswick, N. J.*

"I have read the book, and am both pleased and instructed by it. It gives a clearer account than any I have read before of our coal-deposits. I am confident that whoever reads it will be richly repaid by the information gained, and that its extensive circulation will be useful to our people."

From Prof. LEO LESQUEREUX, *a distinguished paleontologist, and an assistant in the Geological Surveys of several of the States and Territories.*

"It is a work of great value for reference on practical matters concerning the coal: it is full of important facts, and will be not only consulted with profit, but read with interest even by geologists of the highest order."

From Prof. JOHN W. DAWSON, *President of McGill College, Montreal, and author of "Acadian Geology."*

"The work does great credit to the author's industry and research, and will prove of great service to all interested in the coal of the United States."

From Prof. E. T. COX, *State Geologist of Indiana.*

"I regard it as a valuable work, and one that will materially aid in calling attention to the mineral wealth of our country."

From Prof. CHARLES FREDERICK HARTT, *Professor of Geology in Cornell University, Ithaca, N. Y.*

"'The Coal-Regions of America' is a very excellent work, and a valuable contribution to economic geology. I shall place it on the list of the books of reference recommended to the students in my department at this university, and I expect to make good use of it."

From Prof. Frank H. Bradley, *Assistant on the Geological Surveys of Illinois and other States, and of the United States Territories, and Professor of Geology in the University of East Tennessee.*

"I have read Macfarlane's 'Coal-Regions of America' with both pleasure and profit. It seems to me admirably adapted to the present wants of the public. Its careful avoidance of too much technicality on the one hand and too much generality on the other gives us a high opinion of its author. It is neither disfigured by bad theorizing nor loaded with irrelevant speculations. Its positive virtues are too numerous to mention. It should be in the hands of every reader interested in the development of our mineral wealth."

From Prof. C. H. Hitchcock, *State Geologist of New Hampshire, and Professor of Geology in Dartmouth College, Hanover, N. H.*

"I have been greatly pleased with the success the author has gained in the simple, careful, forcible, and yet complete presentation of the subject of coal in this book. To give so fully the structure of the Pennsylvania coal in a small compass is what only a few persons could do. However, it is here given, and in a way that unlearned readers can understand. The maps and sketches are excellent, particularly those of the author's compilation. He has brought together much information from special mining reports, of whose existence I had never heard. The standard misconceptions of earlier authors are not repeated. This is because he thoroughly understands the subject."

From Prof. A. H. Worthen, *State Geologist of Illinois.*

"It seems to be a very complete and comprehensive compilation of what is at present known in regard to the coal resources of North America, and fills an important place in our scientific literature upon that subject. It cannot fail to be of great practical value to all those interested in this important subject."

From the Nation.

"The author has shown much skill and judgment in the selection of his facts, discarding every thing of a strictly scientific nature. He has brought together in a comprehensive manner a large amount of material relating to the structure, position, character, and extent of our coal-fields. This book is not the work of a professional geologist, as is occasionally evident in the reading, but rather, as we are told, of one who gives his experience picked up in the course of sixteen years' active employment in a large coal-business, and it carries indications throughout that the author has watched the progress of innumerable coal-mining companies, studied the causes of their success or failure, and recorded the results of his observations. The interest of the work consists, therefore, not merely in the bringing together of the geological data of coal, but in the consideration of the practical bearing of the science with the important questions of management, production, transportation, and the relation of railways to mine and market. Upon the value of geological surveys Mr. Macfarlane places a high estimate. His opinion, coming from a man of wide mercantile experience, is noteworthy."

From the Daily Graphic.

"James Macfarlane's 'Coal-Regions of America' gets high praise abroad. It is published by D. Appleton & Co."

From the Iron Age.

"From such hasty perusal as we have been able to give this volume, we have no hesitation in saying that it is the most valuable and comprehensive treatise on coal published since the appearance of Taylor's 'Statistics of Coal.' The author has succeeded in collecting a great mass of useful and valuable information, and his book deserves to take rank at once as a standard work of reference, until more thorough and accurate surveys shall have been undertaken which will give to the compiler of such a work additional facts and more complete statistics. The classification of the contents of Mr. Macfarlane's book is admirable, and both compiler and publishers may be congratulated on the literary and mechanical excellence of the work."

From the New York Herald.

"Ever since the publication, more than twenty-five years ago, of the late Walter R. Johnson's 'Government Report on American Coals,' there has been an annually increasing want of a coal manual which should do justice to this vast mining industry. The vacuum is well filled by Mr. James Macfarlane's 'Coal-Regions of America,' which D. Appleton & Co. have just issued in a handsome, illustrated, octavo volume of seven hundred pages. Its numerous maps show all the coal-belts in the various states, so far as yet developed, and its copious and clearly-written text gives the information previously scattered through numerous volumes, periodicals, scientific papers, and unpublished reports, inaccessible to the inquirer. The bituminous coal-fields are here for the first time fully described, while the anthracite regions of Pennsylvania receive adequate notice."

From Appletons' Journal.

"'The Coal-Regions of America,'" by James Macfarlane, just published by the Messrs. Appleton, is one of the most carefully-prepared works of its class. Simple, direct, and without useless technicality, it is not only a thorough treatise, but a book which will be most useful to the ordinary reader, by its refreshing clearness, and the admirable quality it possesses of telling one precisely those facts he most desires to know. The volume has been provided with every thing that could aid the author's work. Excellent maps, among which the large colored one of the coal-regions of Pennsylvania is especially noteworthy, are given everywhere the subject requires their assistance; and the book abounds in good diagrams, geological plans, etc."

From the Popular Science Monthly.

"Besides the special descriptions of the coal-resources of each State, there is a chapter on the iron-ores of the coal-measures, one on the combustion of coal, and one giving the latest statistics of coal mined in the United States and in foreign countries. There is also a very valuable chapter on the conditions of success in the coal-trade. The volume is enriched by a contribution from Professor Newberry on the coal-strata of Ohio, and the author acknowledges important assistance from Professors Cox, Worthen, White, and Foster. Mr. Macfarlane's work is altogether of a very practical character, and will form an instructive contribution to the literature of the subject."

From the American Journal of Science and Arts for July, 1873 *(edited by Professors James D. Dana and B. Silliman), New Haven, Conn., the highest geological authority in the country.*

"This volume is a very important contribution to economical geology by one who has been for sixteen years employed in a large coal-business in Pennsylvania. The author has collected with great assiduity the facts respecting the character, structure, distribution, working, economical value, and other points connected with the mineral coal and the coal-regions of the continent. Although a scientific treatise on the coal-formations was not his object, he has brought in much information on the stratification and geological relations of the coal-measures and their coal-beds. The coal-region and products of Nova Scotia are described equally with those of the United States, and those of the Cretaceous or Tertiary age in the Rocky Mountains as well as the true Carboniferous. The geological map of Pennsylvania is by J. Peter Lesley, one of the best American geologists, who has labored much among the rocks of the State, and especially its coal. This and the other maps and illustrations are excellent."

From the New York World.

"This is a valuable contribution to the stock of information on an important subject, and comes with special appropriateness at a time when the immense rise of coal in Great Britain makes our own stock all the more to be appreciated."

From the Ithaca (N. Y.) Journal.

"Taken all in all, there never has been a work so thoroughly exhaustive on the subject of the coal formation, production, and consumption, as this."

From the New York Independent.

"Mr. Macfarlane's carefully-prepared book is an excellent manual of the subject, and the best one that we know."

From the Elmira Advertiser.

"In many respects it is one of the most valuable productions that has for some time issued from the press. It is full of information, and written in a style that is pleasant to read. It deserves the attention of all thoughtful men, general readers, and students, as well as business-men."

From the New York Times.

"The work contains a very full description of our coal-fields, and will prove of much value, both as a work of reference and as a contribution to the study of the material resources of the continent."

From the London Saturday Review.

"It is a very full, minute, and exhaustive account of the different coal-formations of the United States and Canada. The author shows in detail the situation and extent of the various beds in each formation, their several boundaries, the number and quality of the coal-seams, giving, at the same time, very careful expositions of the geology of each field and basin. He also enumerates the mines at work at each place, describes their character, the quantity of produce, and enters particularly into every circumstance of interest connected with their operation."

From the Albany Argus.

"There is no subject which so combines industrial importance with scientific interest as the one which forms the subject of this large and handsomely-printed volume. We must fail, of course, to give any adequate conception of the immense detail of information contained in the body of the work. The valuable anthracite region of Eastern Pennsylvania, the bituminous region of the western part of the State and of the other States, and the cretaceous coal of the Western Territories, are thoroughly and lucidly analyzed. Each section is taken separately, and every foot of ground and every step in the methods of production carefully and exhaustively set forth. Nothing is left to be desired."

From the New York Evening Post.

"A very comprehensive work on the American coal-regions, which gives their topography, geology, development, and, in general, whatever the well-informed reader and the business-man would wish to know about the coals of our country."

From the Christian Union.

"The books on this subject are in need of revision and extension. This has been furnished by Mr. James Macfarlane in 'The Coal-Regions of America,' published handsomely by D. Appleton & Co. This book, with its numerous maps and illustrations, its clear descriptions of topography and geology, and its accurate and recent summaries of industrial statistics, cannot fail to assume and maintain the position of an indispensable and authoritative manual. The author is a coal-shipper of long experience, whose intelligent and literary tastes have led him to look below the surface of business routine, and to pursue *con amore* the study of the sources from which so many of his fellow-tradesmen are content to draw wealth without further question. The use which he has made of State geological reports and scientific monographs indicates that he possesses a wide acquaintance with the literature of this subject, and a judicious appreciation of the essential and valuable elements among the materials at his disposal."

From the Baltimore Enquirer.

"Mr. Macfarlane has made a very valuable contribution to commercial literature, and, while treating his subject with all the plainness of practical business, he has managed to deprive it of all the dullness and dryness that so often surround this description of subject."

From the Coal and Iron Record.

"The author lays no claim to the character of a scientific man. His acquaintance with coal is, as he states, more that of the merchant than of the chemist and geologist. We are, therefore, prepared to find the work eminently practical, that is to say, it is peculiarly rich in just the kind of information that the coal-consumer and coal-dealer require. Points of special value to these classes of readers are found all through the volume, and in some cases special chapters are devoted to their wants. Among the latter, we may particularly refer to the chapter on 'The Conditions of Success in the Coal-Trade.' But, although the practical aspects of coal in North America have been handled in a manner at once complete and judicious, the scientific relations of the subject have not been overlooked. The book cannot fail to be of great value to all who are interested in the subject of coal."

From the British Quarterly Review for January, 1874.

"The scope of Mr. Macfarlane's work is sufficiently indicated by its title-page. The author has carefully collected all that has been made known concerning the vast coal-fields of the United States. The separate States, as well as the supreme Government, have given every possible encouragement to scientific investigation of the subject. Geological surveys have been made, and their results published. These Mr. Macfarlane has made the basis of his volume. He has condensed and most admirably arranged for reference a vast mass of information into a bulky, but yet compact and lucid, hand-book. It cannot be supposed that all is known that will be known. The mineral and carboniferous treasures of the States are developed and known only in part, as every other class of of their illimitable resources are known, but all that has been discovered is here tabulated. Mr. Macfarlane is a practical coal-inspector, and, for many years, has assiduously gathered from all reliable sources the information which he gives in his book. Its character is commercial rather than scientific. One cannot but admire the great future which the coal formations of North America alone insure it. They extend over 192,000 square miles, while those of Great Britain are only 11,900, and those of Nova Scotia 18,000; and are not only very varied—bituminous and anthracite, cretaceous and triassic being alike abundant—but they are widely distributed, and generally the coal is near the surface. As yet, three times as much coal is produced in Great Britain as in the States. Practical suggestions and comparative statistics are given. Mr. Macfarlane writes sensibly, lucidly, and modestly, and contents himself with the statement and exposition of facts. His work is many 'Blue Books' in one."

From the Geological Magazine, London, January, 1874.

"Mr. Macfarlane's work forms a most important addition to the geological literature of coal, and, being well posted up as regards all the latest reports of the Government surveys, conducted by the best geologists in the United States, it may be looked upon as a most valuable addition to, and even as superseding to a great extent, those works on the subject published some years since—such, for instance, as Taylor's 'Statistics of Coal,' and Prof. Rogers's 'Geology of Pennsylvania.'"

The article gives extensive quotations from "Mr. Macfarlane's admirable work," as it calls it.

From the Colliery Guardian, London, October, 1873.

"This is a handsome volume of nearly seven hundred pages, richly illustrated with diagrams, maps, sections, and other engravings, and appearing, as it does, just at the moment when the eyes of Europe are turned toward the United States, with their vast stores of coal, it will be read with special interest."

From the Iron and Coal Trades Review, London, April, 1874.

"To all who would make themselves acquainted with the marvellous mineral resources of the United States, the study of the work under notice cannot fail to be exceedingly interesting. As a work of reference, it will also be of great value."